A User's Guide to the GSFC Flight Planner Software

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Introduction

1.1 Rationale

A scientist with a pencil and paper can certainly sketch out a flight plan in consulatation with a pilot. He can even work out tentative plans on his own for submission to the flight crew later. But the futher the scientist gets from the cockpit, the more error-prone the process becomes. Using a single air speed or fuel burn rate can be sufficiently accurate for the middle of a flight, if there is no vertical maneuvering, and if the takeoff and landing do not need to be taken into account. But all too often, even the best scientists find themselves prone to making simple math errors while estimating in their heads, especially under the pressure of a field campaign. Equally error-prone is the practice of flipping between web pages to compare maps of data constructed using different scales and map projections for different times. A software tool to help avoid these errors can be helpful.

To illustrate, consider this real-world math problem:

> Your car gets 26 miles to the gallon of gasoline. There are two filling stations near your home. One is two miles way, and the other is five miles away. The nearer station's price for gasoline is consistently higher than the farther station's. If you need 10 gallons to fill your tank, how much higher does the price difference between the two stations need to be before you can save money by driving the extra distance to the second station?

Imagine handing this question to people who know nothing about algebra. Most will struggle, restarting several times as they realize they have omitted factors that they need to consider. Some will get a wrong answer through a wildly wrong approach. But most people are smart enough to stumble through a correct reasoning process, even if many are thrown off by an elementary arithmetic error in the process.

For someone who knows algebra, however, it's a straightforward problem to solve: identify variables, set up an equation, and solve for the unknown. Rather than struggling with each simple step in the reasoning process, we can rely on the rules of algebra to take care of those steps automatically. The rules of algebra are no substitute for thinking, but they do reduce the need to focus on each individual step. The thinking comes in setting up the initial equation and in interpreting the result. Algebra makes the intermediate steps easy and automatic, reducing the likelihood of error.

In much the same way, computer software can assist in planning science flights. While it must not be used as a substitute for thinking about sampling strategies and aircraft capabilities, a flight planning tool can be very helpful. It can automatically estimate such things as flight time and fuel consumption. It can remind scientists of airspace boundaries while providing them with views of current scientific conditions to be measured. By getting the minor detauils right, it can free the scientist to think about the bigger issues of the campaign.

1.2 History

Aircraft-based field experiments have played an crucial role in the atmospheric sciences. By mounting *in situ* and remote-sensing instruments on an airborne platform, scientists can assemble a more detailed set of measurements than is possible with satellite soundings and cover a wider geographical range than is practical with ground-based measurements. To use an aircraft to best advantage, however, it must fly through areas that will provide the most scientifically interesting measurements. The days are past when an aircraft carrying instruments could take off and take interesting data no matter where it flew.

During a series of NASA aircraft field experiments in the early 1990s, the need became apparent for a graphical software tool that would help mission scientists determine what kind of flight path would be most desirable for enhancing science results and would help communicate their desires to the flight crews. Scientists needed to be able to call up meteorological forecasts and to plot maps and vertical cross-sections with proposed flight tracks superimposed.

There is also a need for flight paths thus obtained to be communicated to the flight crew. Coming from different professional worlds, the aviation side and the science side of a field mission frequently find themselves pulling in different directions. The aviation community is very much aware of boundaries such as restricted airspace and international borders. The scientific community is focused mainly on the atmospheric phenomena being studied—phenomena which pay no attention to man-made boundaries. Aviators know that various permissions must be arranged with government agencies in order to do anything unusual with an aircraft, and that the more advance time there is before takeoff, the more likely those permissions are to be granted. Scientists on the other hand understand that atmospheric phenomena are often short-lived and fast-moving, and that a precise flight plan negotiated months in advance will almost certainly be unable to sample the air that is needed. Ultimately these two communities with differing perceptions and agendas must find common ground and resolve the tensions that tend to pull them apart. A good flight planning tool for the scientists can help.

Created in 2008 by researchers in the Atmospheric Chemistry and Dynamics Branch of NASA's Goddard Space Flight Center, the flight planning software described in this manual is intended to fulfill these needs.

1.3 Basic Concepts

In order to use the flight planning software to best effect, it is important to have an understanding of some basic concepts. The first thing to note is that a flight plan is more than just a series of way points on a map. In this software, a flight plan is a sequence of maneuvers, each of which changes the state of an aircraft. For example, a takeoff maneuver will take an aircraft which is at rest on the ground and transform it into an aircraft flying at a certain altitude, speed, heading, and instantaneous location. A turn maneuver will transform an aircraft with one heading into an aircraft with a different heading. The output state of one maneuver serves as the input state of the next; by using a sequence of maneuvers to take an aircraft from one state to the next, the flight planner seeks to simulate the flight, including simulating intermediate states within each maneuver. This turns out to be a powerful idea that lets simple flights remain simple ("travel to way point A, then travel way point B, then . . . ”), but allows for complicated three-dimensional operations where needed.

The next key concept used by this software is the idea of separating the displays from the plan itself. That is, the plan is not inextricably linked to a certain map upon which you edit way points (although you can certainly use a map to edit your way points). Rather, the plan exists independently of any single display, and the displays are all ways of visualizing the the plan. For example, you can bring up a map that shows a wide overview of the entire operations area, plus a different map that shows a tightly zoomed-in portion of the flight, plus yet another map that shows meteorological data with the overlaid flight path. Each map can be used to examine and change the flight plan. All displays are equal in the sight of the software. You determine how many and which kinds of display are most useful to you.

Putting these these concepts together give you the hierarchy of graphical controls you will be using. At the top of the hierarchy is the entry control; you use this to create or load flight plans, which leads to the next level of the hierarchy: the flight plan control panel, one for each plan that you are working on. The third level of the hierarchy consists of the various displays you can bring up from each flight plan control panel. Each display is associated with its parent plan's control panel. Keeping this hierarchical relationship in mind should help you as you use the controls.

1.4 Applicability

Unsurprisingly, the Goddard flight planning software works best in predictable, plannable situations. The applicability of the flight planner is therefore limited by two principal factors: the predictability of the aircraft and the predictability of the phenomena being sampled by the aircraft's instruments.

The software simulates the behavior of some aircraft better than others. It does the best job with those platforms which operate within limited conditions: a well-defined airspeed as a function of altitude, a simple profile for its ascents, and a constant rate for its descents. Consequently, it does its best job with the Global Hawk and the ER-2, which operate within fairly narrow limits. Other aircraft such as the Gulfstream V and DC-8 exhibit a higher degree of variability in air speed and rates of ascent and descent. The flight planner's default settings provide reasonable average values for these aircraft, and the default settings for individual maneuvers can be overridden to pro-

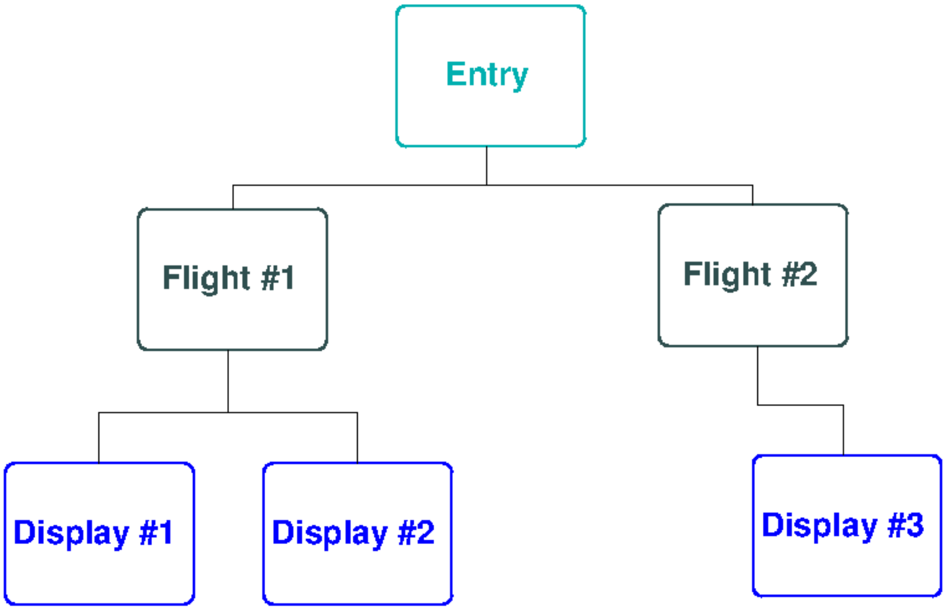

Figure 1.1: The graphical control hierarchy

vide improved levels of accuracy. But much of the variability in an actual flight is a result of pilot choices made in real time during the flight, and these are not planned or predicted in advance. But even with these aircraft, the flight planner provides a more accurate estimation than the typically-used assumptions of a constant horizontal air speeds and no vertical motions.

The second factor, the predictability of atmospheric phenomena, is largely dependent of their scale; the position of the polar night vortex is more accurately forecast than thunderstorms. But modern models are able to forecast areas of likely thunderstorm activity with some accuracy. While it is true that detailed plans for storm-chasing flights cannot be made in advance, it is also untrue that plans must be completely thrown out as soon as the aircraft takes off. Especially when model forecasts indicate several possible areas of scientific interest, it is worthwhile drawing up a rough baseline plan to get a feel for the timings of possible alternatives.

A potential third factor to consider is the simplicity with which maneuvers are represented within the flight plan, but as a user you have a high degree of control over this. For example, the default way this software makes turns is to keep the aircraft fixed in one location and pivot it into its new heading. The time to make the turn is calculated in a realistic way, but the spatial path is not. For large-scale flights, the discrepancy is insignificant. But for small-scale maneuvers, where straight-leg segments are comparable in length to the arc of the actual turn, the discrepancy may be unacceptably large. In those cases it is up to the user to recognize the situation and use another, more appropriate, maneuver such as a partial circle path, to accomplish the same end with the desired degree of fidelity. The choice of maneuvers, the choice of horizontal speed, the choice of ascent and descent rates—all are at your disposal to create a realistic flight plan, limited by the time and effort you are willing to put into it, as well as the predictability factors already mentioned.

In summary, using the Global Hawk or the ER-2 to examine large-scale features is likely to yield an accurate simulation of a proposed plan. And using a smaller, more maneuverable aircraft to explore smaller-scale storm systems will result in a less accurate plan. But in either case, it must be stressed that the flight planner software is no substitute for discussing your plans with the aircraft flight crew. **Always remember that the point of using the flight planner is to test ideas for plans and examine their feasibility. The goal is not to attempt to create a detailed program to be fed into the aircraft and flown exactly. In this way, the flight planner really produces not plans, but proposals for flights.**

Chapter 2

Getting Started: A Tutorial Exercise

2.1 Running the Flight Planner

Before you run the flight planner, you should make sure that your shell environment and your X11 resources are set up for it. If you are running with access to the /science data system in the NASA GSFC Atmospheric Chemistry and Dynamics (ACD) Laboratory, your environment is already set up for you. If you are on the ACD Unix Cluster, but you normally do not use the /science system, you might need to give the command "`source /science/atmos.cshrc`" (for csh/tcsh users) or "`source /science/atmos.profile`" (for bash/ksh/sh users). The flight planner uses a facility of the X11 windowing system, called "resources", to determine the color of various graphical user interface (GUI) elements. If you want the various GUIs to appear in their proper colors, then you will also need to load the proper resources into your X server, using the command "`xrdb -merge /science/missions/fltplan/data/flightplan.xrdb`".

If you are outside the ACD Cluster, then you will have a compressed tar file archive containing all the files that you need. Unpack this "tarball" in a place of your choosing. Assuming you are using the bash shell, then look for the setup.sh script in the distribution of flight planner code, wherever it was installed on your computer. The command "`source setup.sh`" should set up all of the shell environment variables that you need, and it also sets the resources of your X server. (Of course, your environment might be different enough from what we expected, that you will need to tweak the "`setup.sh`" script to get it to work.) Also, be sure that you are running X11!

If you are on an Apple Mac, and you have installed the software, then all you should need to do is run the application that gets installed, and it should do all the setup for you.

If you would like to follow along with exercise below, then find the "Training" directory with your flight planner distribution, or copy "`/home/lait/Missions/glopac/fltplan/Training/`" into your home directory on the cluster.

In this example, we will plan a flight for the NASA ER-2 aircraft, taking off from Dryden Flight Research Center and going out over the Pacific Ocean. We will set up a few simple displays, we will edit the flight plan, and then we will save our work and make files for hardcopy output.

To start running the flight planner, get into the IDL interpreter and give the command "flightplan".

In this manual, we will refer to top-level GUI components that occupy their own windows as Widgets. Within each Widget there will be a number of buttons, sliders, menus, and text entry blanks that we will refer to as *controls*. Note the typographical distinctions, since they will be used throughout this manual.

2.2 The Entry Control

When you first enter the flight planner, a Entry control panel appears. (See Figure 2.1.) This panel has a tool bar with a single item, File, which offers three choices: New flight plan, Open flight plan, Export all flights' displays, and Quit.

Let's begin flight planning by clicking on New flight plan.

2.3 Creating a Flight Plan

When you start planning a new flight, a pink Start New Flight widget appears. (See Figure 2.2.)

The first thing to select is the kind of aircraft you are using; click on one of the buttons. Next, type in the aircraft ID; this can be a tail number

Figure 2.1: The Entry Control

or any other identifier that your mission finds useful—it is used merely to distinguish different aircraft if you are planning for several at the same time.

Next, type in a nominal duration for the flight, in decimal hours. This number is used to make certain estimates (for example, estimating the mid-point of the flight, at which meteorological fields are displayed). This does not have to be exact, but it should be close.

(Ignore the button for setting aircraft parameters; that is for very advanced and specialized purposes only. Using it requires detailed knowledge of the internal workings of the software.)

Now switch to the Initial State tab, as shown in Figure 2.3 Type in a date and time for the takeoff, in ISO 8601 format. for example, "2012-05-03T02:12" is a takeoff at 02:12 UTC on May 3, 2012. Note that all times used by the flight planner are Universal Coordinated Time (UTC). (You can display the time for some local region in certain reports if you wish, but internally the software uses UTC.)

Setting the initial state of the aircraft comes next, with several controls to specify where the aircraft is and how it is moving at the start of the plan. Most of your plans will probably take off from rest at an airfield, and land at an airfield. In those cases, the elapsed time at the beginning of the plan

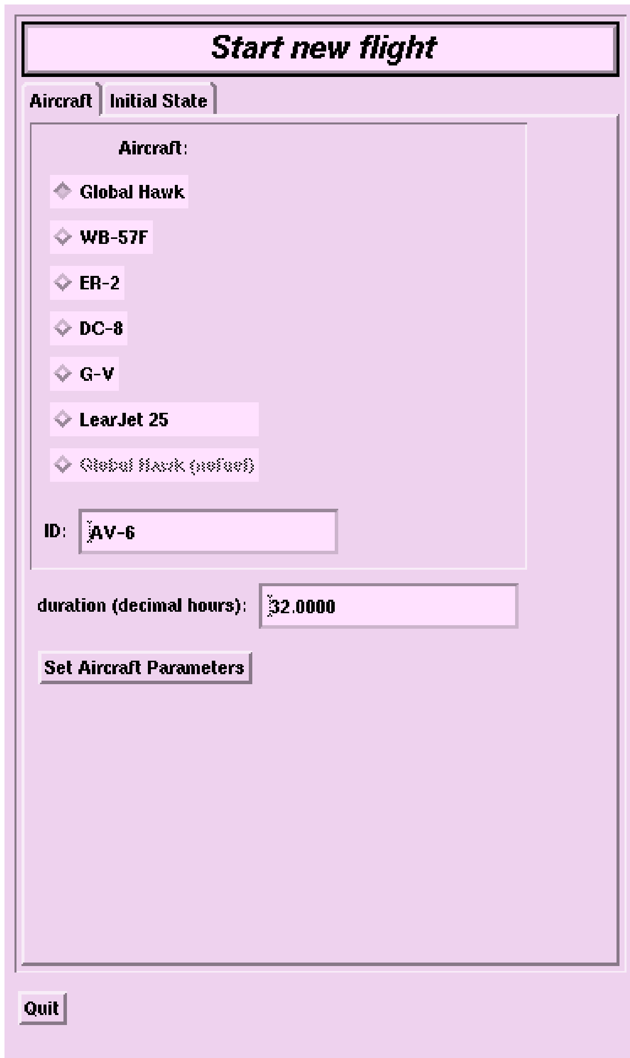

Figure 2.2: The Start-New-Flight Widget

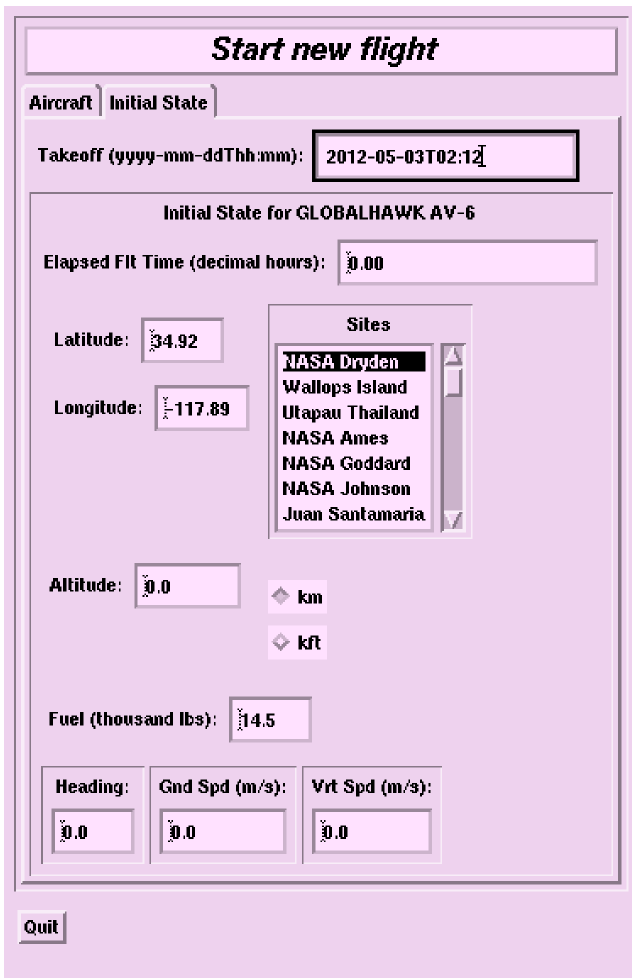

Figure 2.3: The Start-New-Flight Widget, initial-state tab

will be 0.0, and the initial altitude will be 0 or close to it. You can specify the latitude and longitude of the takeoff site if you wish, or you can click on one of the sites in the list as a shortcut. Leave the ground speed and vertical speed at 0, since the plane starts at rest. You can set the heading to the runway direction if you like, or you can leave it as 0 here and specify a takeoff heading when you begin adding maneuvers.

Here we are taking off at rest, but you can create a plan that starts in the middle of a flight if you need to. You might want to do this in order to work out the timing of a proposed maneuver while the aircraft is flying. In that case, set the elapsed time to the time after takeoff at which you want the plan to begin, and set the takeoff time to the time the aircraft actually took off from the airfield. Set the latitude, longitude, and altitude to that of the aircraft in flight at the time you specified. Set the heading, ground speed, and vertical speed at this point, and you can proceed.

Click on the *Start new flight* button at the top to begin planning this flight, or click on the *Quit* button at the bottom to abandon it.

For our exercise, choose the *ER-2* aircraft. Use the default takeoff time and flight duration. Choose *NASA Dryden* as the initial location, and 0 as he initial altitude (although you can use the actual altitude of the runway at Dryden Flight Research Center, 0.665074 km).

2.4 The Flight Plan Control

Once the flight plan has been started, a dark green Flight Plan control panel (or "widget") appears. As seen in Figure 2.4, this widget has a row of information across the top, and then two tabs just below that: *Basic Specs* and*Editing*.

The top row has controls for setting the takeoff time and flight duration; these which work the same as they did in the Start-New-Flight widget. In addition, there are displays of the total time and distance of the current plan. For some aircraft, the software estimates the fuel expended during flight; that is displayed here as well.

2.4.1 The Basic Specs Tab

The first tab that you see is the *Basic Specs* tab. This tab is for specifying a few basic identification aspects of the plan such as its name and version.

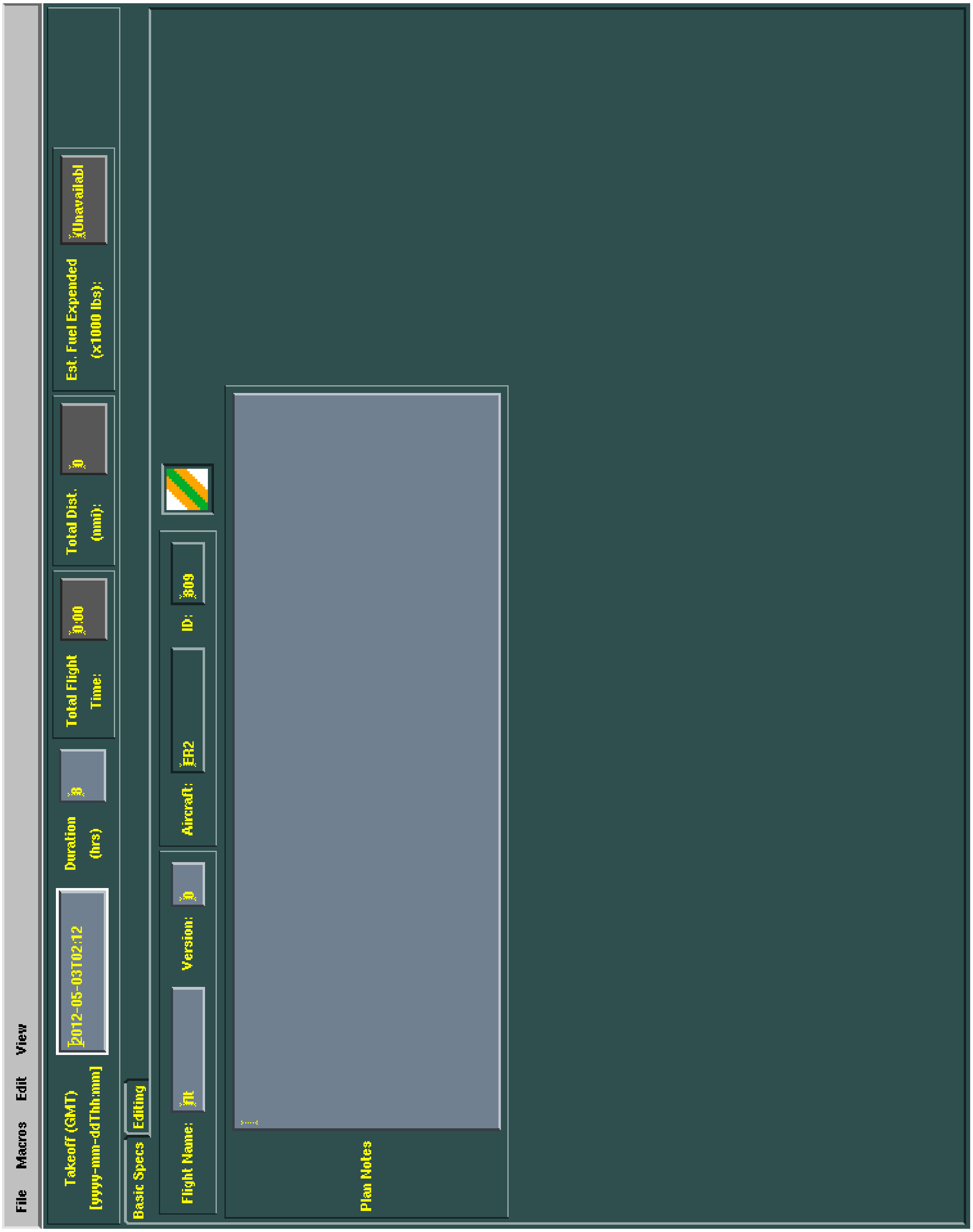

Figure 2.4: The Flight Plan Widget, Basic Specs tab

As you plan flights for a field experiment, you will find it important to be able to keep track of various iterations of plans, with their multiple alternatives for multiple days. It is strongly recommended that you adopt a naming convention for your plans and follow it faithfully. One good convention is to use the mission name or abbreviation, followed by the proposed flight date and/or flight number. For example, if the third flight of the "GLITCH" campaign is to take off on July 15, 2010, you might want to name the flight "glitch_3_2010-07-15". If multiple aircraft are flying during the campaign, you might add the aircraft type to the name, too. As you make revisions to this plan, you will save yourself much trouble if you save each revision under a different version designation. A simple convention is to use a single integer (i.e, versions 1, 2, 3, and so on), but like the name the version can be an arbitrary string. If you are making plans in coordination with other people, you might each ad your initials to the version. Again, choose a convention that works for you and then stick with it throughout the campaign.

Note that some areas in the control are shown in light gray. These are areas that you can change. Some other settings, such as aircraft type and ID, cannot be changed at this point.

So start by typing "test_plan" into the *Flight Name:* entry blank, and leave the *Version:* blank as 0.

A large space below the top row is labeled *Plan Notes*. This is for comments about the plan, such as its scientific objectives, special points of note, or any other remarks that would be useful for someone reading about this plan. (These notes can be included in any of several reports that the software can produce, so they will be seen.) Type "This is a test" here.

You will also see a colored square in the top right area of the controls. This button lets you set the colors with which this flight track will appear in plots. When an aircraft path is plotted as a line on top of a false-color image (either on a horizontal map or a vertical curtain), sometimes the line's color is hard to see against portions of the image background. To avoid this problem, the flight planner draws such lines in two colors, a thin line overlaying a thicker line. If you click on the color button, a Flight colors control panel appears, as shown in Figure 2.5. You can use these two controls to set both colors; by setting them to appropriately contrasting colors, the flight path should show up clearly no matter what any background image looks like underneath it. Alternatively, if the two colors look too garish for your tastes, you can set them to the same color.

The color of nearly everything that can be drawn on a graphical display

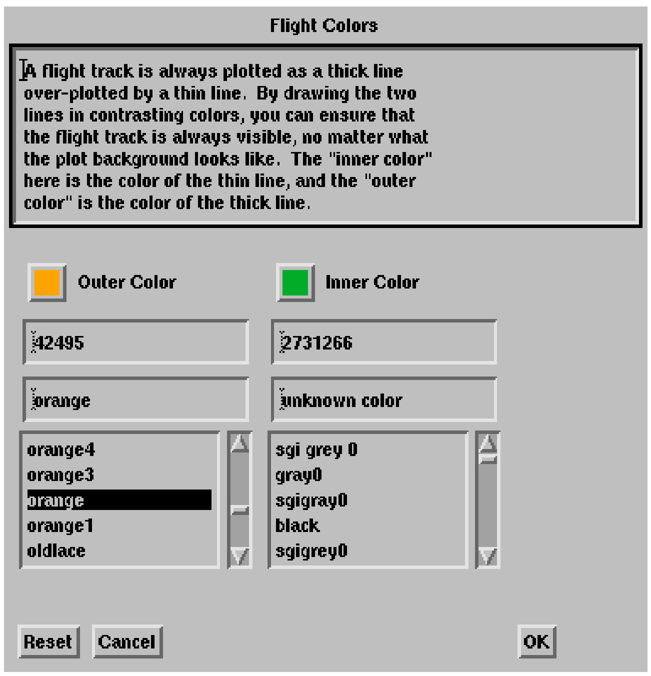

Figure 2.5: The Flight Colors Widget

can be set by a control associated with that display, *except* for the flight track. That color is set here on the *Basic Specs* color controls, and only here. The reason is that as you make different plot displays, with perhaps flight paths of multiple aircraft, you really need to use a consistent set of colors for each flight path that applies to all your displays.

Since similar controls set nearly every color that can be set in the flight planner, it is worthwhile to learn how to set colors now. You will see several items under *Inner Color*: a numeric display, a single-line text display, and a text list of colors. You can scroll up and down the list of colors and then click on one to select it. You should note that the list is ordered by color, not by name. That is, all the blueish colors tend to be together, and all the reddish, and so on.

However, there is not a lot of space for scrolling lists, and in the small area allotted moving around in the list may be hard to do. That is where the single-line entry comes in: type in the name of the color that you want and press the Enter key. Three things change: the square button changes color, the list scrolls to the color that you typed in (if it is in the list), and the color number for your color appears in the numeric display. This single-line text entry can also be used to move the scrolling list to a group of colors that contains the color you want (but whose exact name you do not remember). For example, if you want a color that is kind of pinkish-red, type "red" and the scrolling list flips to the reddish–looking colors; then scroll down a little and pick "salmon" from the list. If you already have the 24-bit integer numeric representation of a color, you can type it directly into the numeric display. Usually, this will be a hexadecimal value, so precede it with "0x". The first two hex digits will be the blue value (00–ff), the next two are green, and the last two are red. Note that this ordering (BBGGRR) reflects the way the IDL handles 24-bit color integers. It is exactly the opposite order of color integers used in, say, web design. So If you read a color from a web site as "0x123456", then you will want to enter it here as "0x563412".

The color that you select in one of these three ways is displayed in a colored square just above the selection controls. But there is a fourth way of choosing the color: click on the colored square, and you will get a new widget that lets you see a color as you set its numeric components. You can even select the color system that you want: RGB, CMY, HSV, and HLS. Click *Done* when you have the color that you want. The color name becomes "unknown color", but the numeric display shows the RGB value of what you chose.

As an exercise, see if you can choose the colors "royal blue" for the inner color and "0x7185F0" for the outer color. Then click on the *OK* button. Note that the diagonal line through the button on the Flight Control panel has changed its colors.

2.4.2 The Editing Tab

Click on the *Editing* tab. The control panel now looks like Figure 2.6. Note there are three main areas aside fomr the top row above the tabs: the right side lets you create and edit defined locations, the left side displays an editable list of the maneuvers that make up the flight plan, and the bottom row has controls that affect the maneuvers.

The right side of the panel manages defined locations within the plan. What is a "defined location"? Well, suppose all way points in a flight plan maneuver were specified individually in terms of their latitude and longitude coordinates, and suppose that a particular way point were used in several maneuvers. Then if you decided to move that way point, you would have to go through each of those maneuvers and change its latitude and longitude. It would be much better to define a location (a specific latitude/longitude pair) with a symbolic name, and then refer to that symbolic name in the various maneuvers. The flight planner lets you keep a list of these defined locations for use in the flight maneuvers that make up a flight plan, and this set of controls on the left side lets you manage those definitions. Note that the table already has a point defined, "Origin", which is the starting point of the plan.

Click on *Add* to add a new location. A new point appears in the table whose name starts with "P" and which is at latitude 0, longitude 0. Click on the name, type in a new name ("AA"), and press the Enter key. Similarly, change the latitude and longitude to 25 and -150, respectively. You can leave the other columns in the table blank for now. The "Type" column is for classifying locations into different groups such as way points, dropsonde locations, reference points, and so on; these are arbitrary strings, and you can use a convention of your own devising for your own convenience. "Off. ID" stands for "Official ID" and is used in certain reports for locations that are defined by civil aviation authorities. The "Notes" column is for whatever remarks or annotations you feel you may need.

Various reports that the software generates can include this list of locations, and they will appear in the same order as they appear in the table

Tip:

In most places, you can enter longitudes and latitudes in any of several formats: ("`45.6`", "`-173.23`"), ("`45o35'59"N`", "`173o13'47"W`"), or ("`N 45-36.00`",

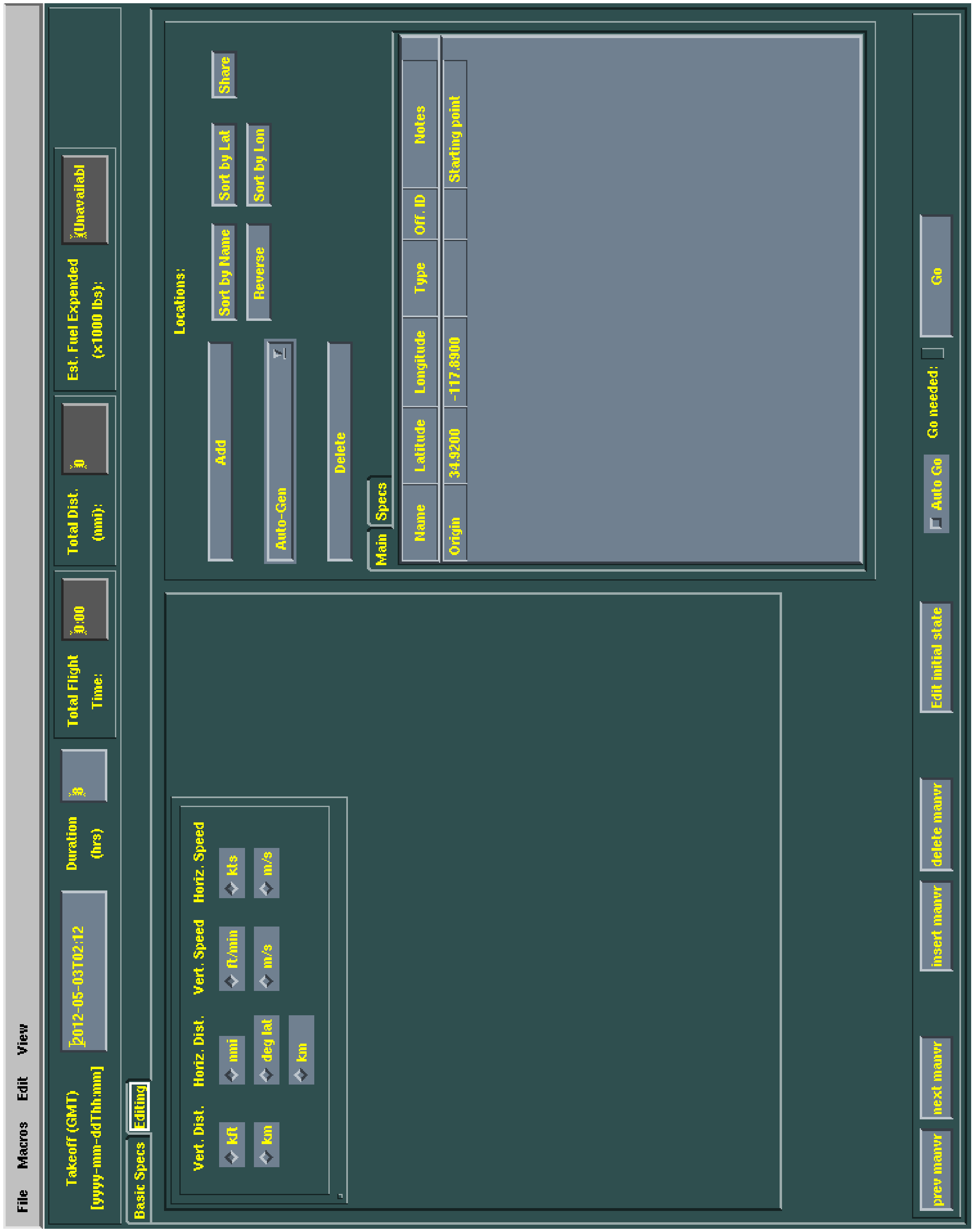

Figure 2.6: The Flight Plan Widget, Editing tab

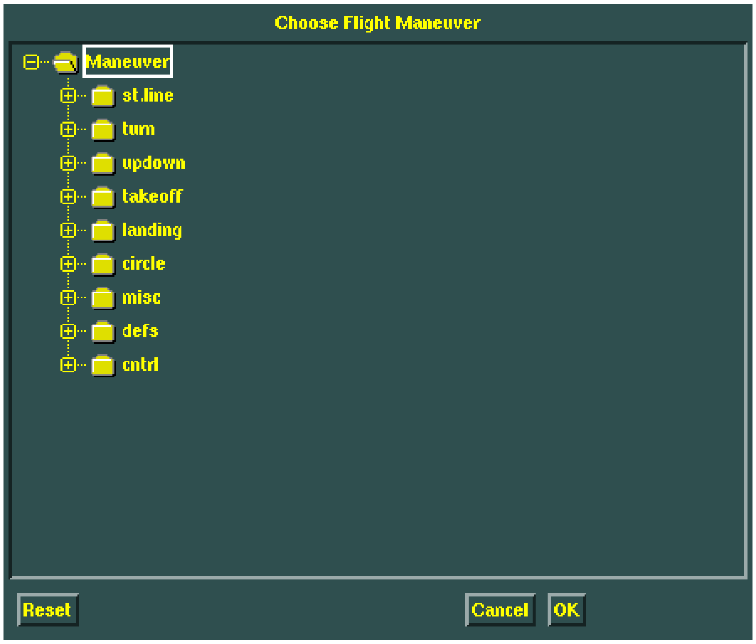

Figure 2.7: The Maneuver Choice Widget

here. There are buttons just above the table that let you sort them by name, by latitude, or by longitude. There is also a button for reversing the order of the list.

You can ignore the other buttons in the right side for now, as well as the *Specs* tab—those are for advanced use.

The controls on the left side comprise the core of the flight planner. Right now, your new plan is empty, and the only controls that you see are those which set the units you will be using. Depending on circumstances, sometimes you want to specify distances and speeds in aviation units (nautical miles, thousands of feet, and knots) or scientific units (kilometers and meters per second).

Let's add a maneuver. Click on the *insert manvr* button, and the maneuver selection panel will appear, as in Figure 2.7. Note the various categories of maneuvers. Click on the *takeoff* folder icon to display the maneuvers that have to do with takeoffs. Double-click on *Take off at a given heading and ascend to a given altitude*. The maneuver selection will disappear, replaced with an editing widget for the maneuver you selected, as in Figure 2.8.

As with most regular maneuvers, you will see several tabs. the one that

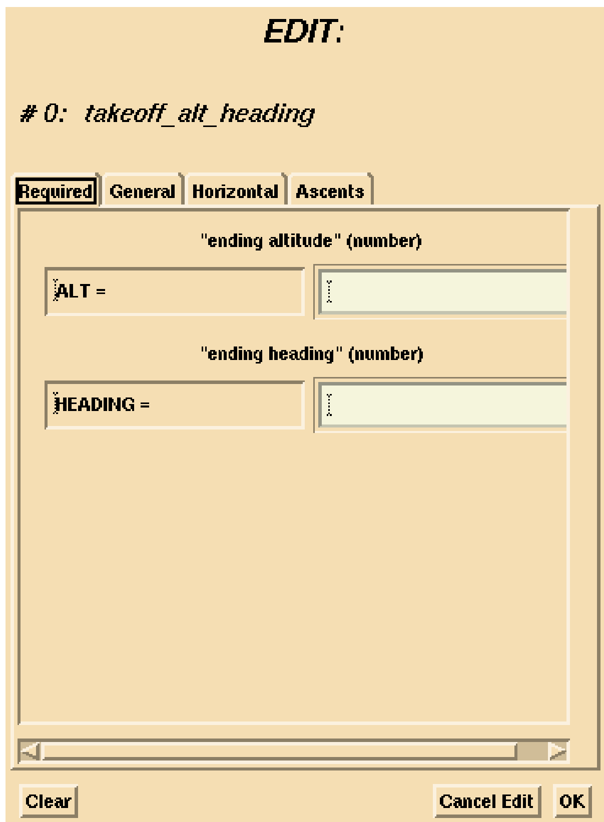

Figure 2.8: An editing widget for a maneuver

you see first shows the required parameters for this maneuver. The *Take off at a given heading and ascend to a given altitude*, or *takeoff_alt_heading*, maneuver requires two parameters: the heading the aircraft should have during its initial ascent, and the altitude to which it should ascend. The thing about required parameters is that they must be specified and cannot be left blank. Since the aircraft is an ER-2, type 56 into the *Altitude* entry blank. (Remember, we have the vertical distance units set to kft, or thousands of feet, so this is 56,000 ft.) For heading, type in -100, for 100 degrees counterclockwise from north.

Depending on the maneuver, there may be other tabs with optional parameters. You may (and usually will) leave these parameters blank, which cause default values to be used for this aircraft under these conditions.

The *General* tab lets you specify SPEED and TAS_BOOST. SPEED is the ground speed that should be in effect for this maneuver. Often, you do not know or care what speed you want; you just want the aircraft to be a little faster or slower. In that case, use TAS_BOOST, which is a ratio by which the default ground speed will be multiplied. Thus TAS_BOOST = 1.2 increase the speed by 20%, and TAS_BOOST = 0.90 will decrease the speed by 10%.

The *Horizontal* tab has just one parameter, PATH_TYPE. This is a string, either "rhumb" or "grcirc". The former specifies that the aircraft should travel along lines of constant bearing (rhumb lines). (This is valid only for latitudes equatorward of 80 degrees.) The default is "grcirc", which specifies that the aircraft should travel along great circle lines on the sphere.

The *Ascents* tab takes two parameters, BOOST and RISE_RATE. RISE_RATE sets a constant used in the equations used to calculate the asymptotic rise of the aircraft. Just as with ground speed, you may want to change the BOOST parameter, which multiplies the default RISE_RATE value. A BOOST value of 1.5 will cause a more rapid rise, and a BOOST value of 0.5 will cause a slower rise.

Once you have all parameters set the way you like, click on the *OK* button in the lower right corner. The takeoff_alt_heading editing widget disappears, and a new maneuver control appears in the maneuver list on the left side of the Flight Plan widget, which now looks like Figure 2.9.

The new control has the name of the maneuver along the top, and a digest of the required parameters on a button in the middle. (If you click on this button, the takeoff_alt_heading widget will reappear so that you can edit the parameters.) At the right top is a *Del* button; click this to remove this

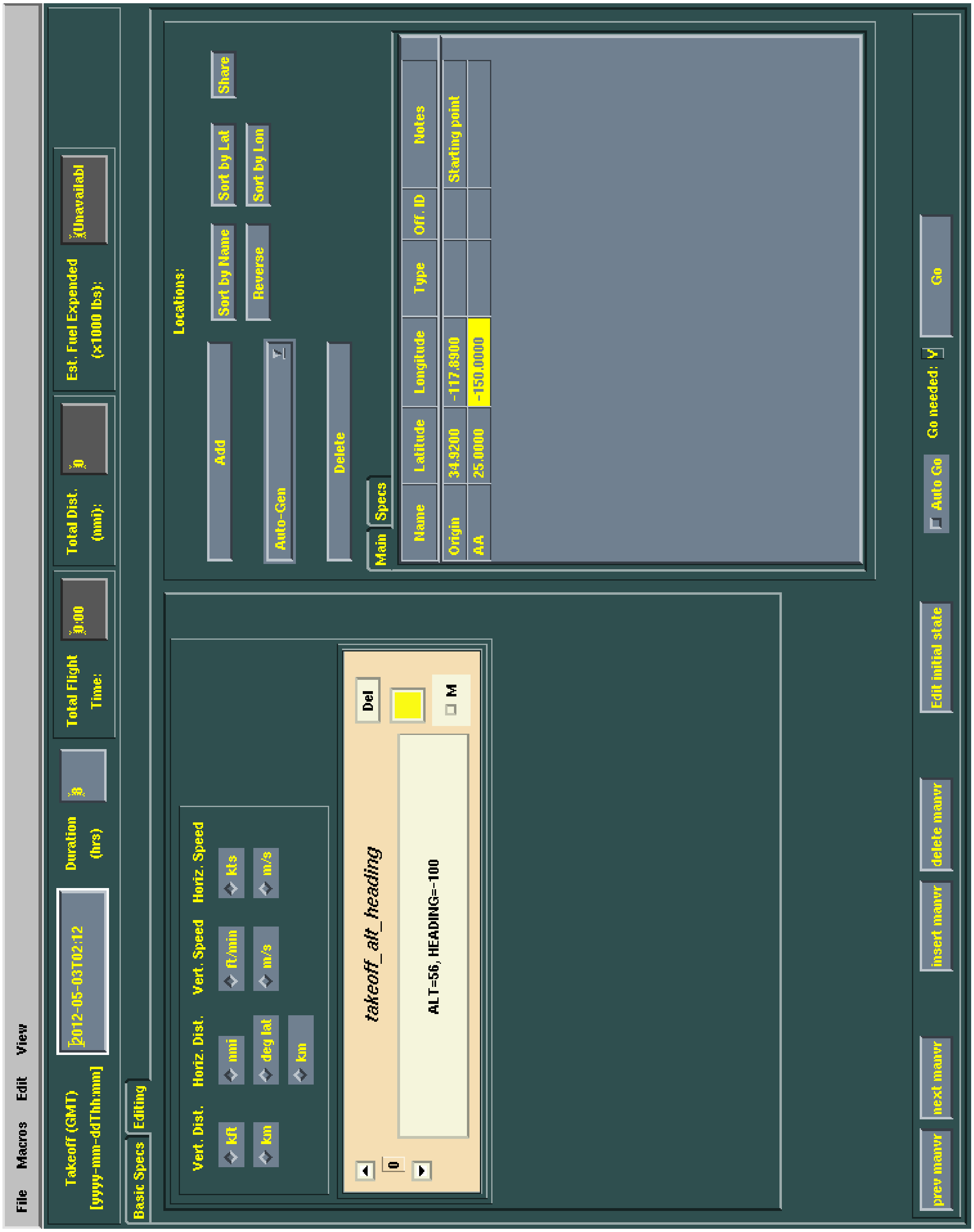

Figure 2.9: The Flight Plan Widget, with a maneuver

maneuver from the plan. Below that is an indicator light. Just to the left of the central button is a number; each maneuver in the list is numbered, and this number shows you which is which. Above and below the number are little arrow buttons; you click on these to insert a new maneuver into the plan, just as with the *insert manvr* button at the bottom. The difference is that the *insert manvr* will insert the new maneuver just after the maneuver that has a yellow indicator light, and the arrow buttons will insert it just before or just after the maneuver whose arrow buttons you clicked on.

Click on the downward arrow button on the *takeoff_alt_heading* maneuver. The Choose Flight Maneuver panel reappears. Open the *st.line* category and double-click on *Cruise climb to a given location*. Type "AA" into the LOC parameter of the cruise_toloc editing widget that appears, then click on the *OK* button. Now the maneuver list has two maneuvers in it.

Now look at the bottom row, towards the right. There will be a check in the *Go needed:* box. This means that you have made editing changes to you plan, and the plan need to be simulated. Click on the *Go* button. Note that as a result the *Total Flight Time* and *Total Dist.* displays on the top row are updated. The panel now looks like Fig 2.10.

You can actually plan a whole flight using just these controls on the Flight Plan panel. But you would probably find that cumbersome and awkward. So let's proceed to open a map display for this flight and use it to edit the plan graphically. Go to the *View* menu on the toolbar at the top of the Flight Plan Choose *EditMap*.

2.5 EditMap Display

The EditMap Display widget that comes up should look something like Fig 2.11.

Before we start fiddling with the flight plan, note the controls along the top row of the Map Display widget. The *Plot* button triggers a re-plot of the display when clicked. To the right of this is a *Need Replot* indicator; when this has an asterisk, the plot is out of date, and you should click on *Plot* button. The next control is *Auto Replot*; this toggles whether the plot is automatically re-plotted (as if you had clicked on the *Plot* button) whenever the *Need Replot* indicator shows an asterisk. By default, this is on. But if you need to make a number of changes, and you don't want the plot take the time to refresh after each change, then you should turn this off momentarily.

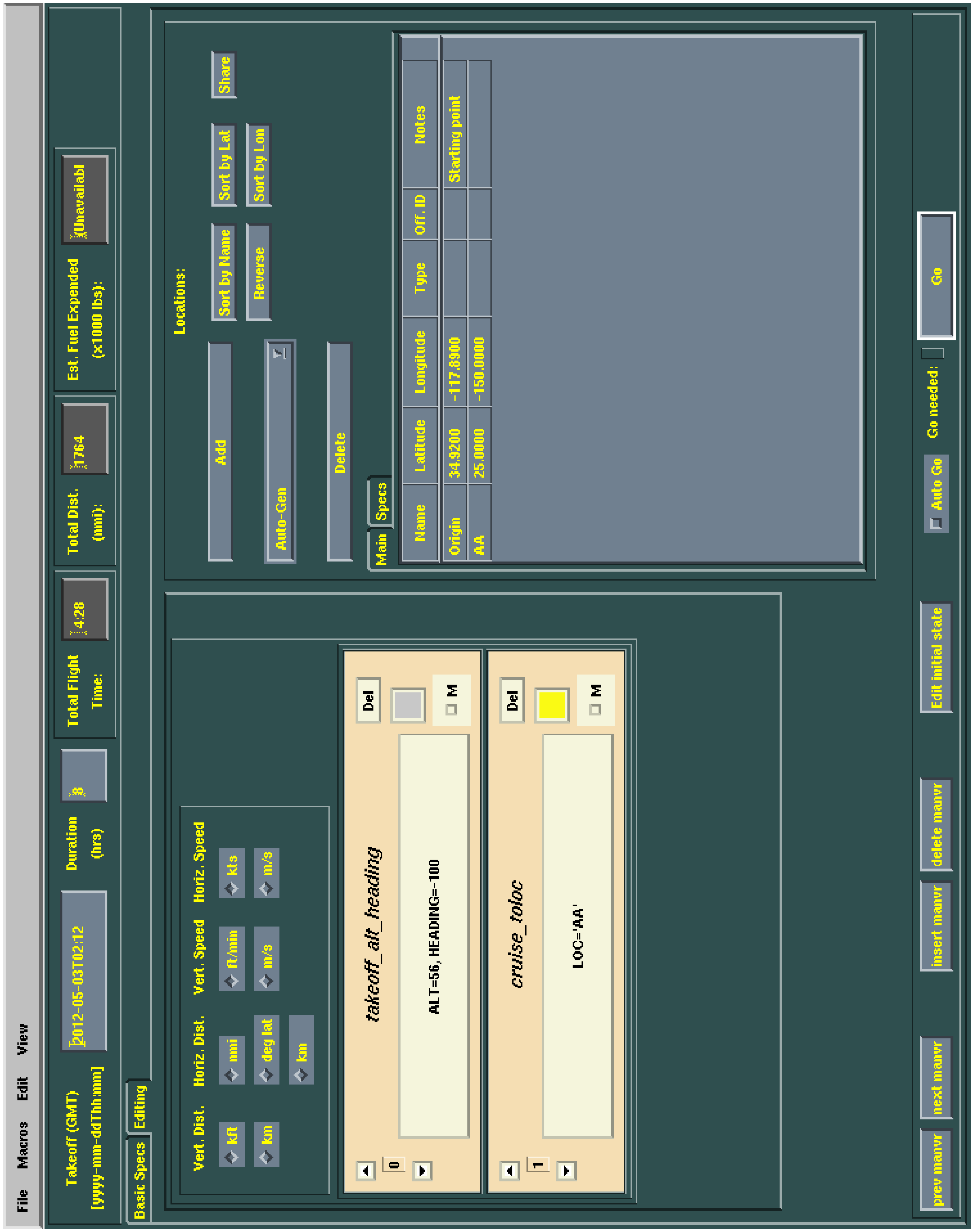

Figure 2.10: The Flight Plan Widget, after editing

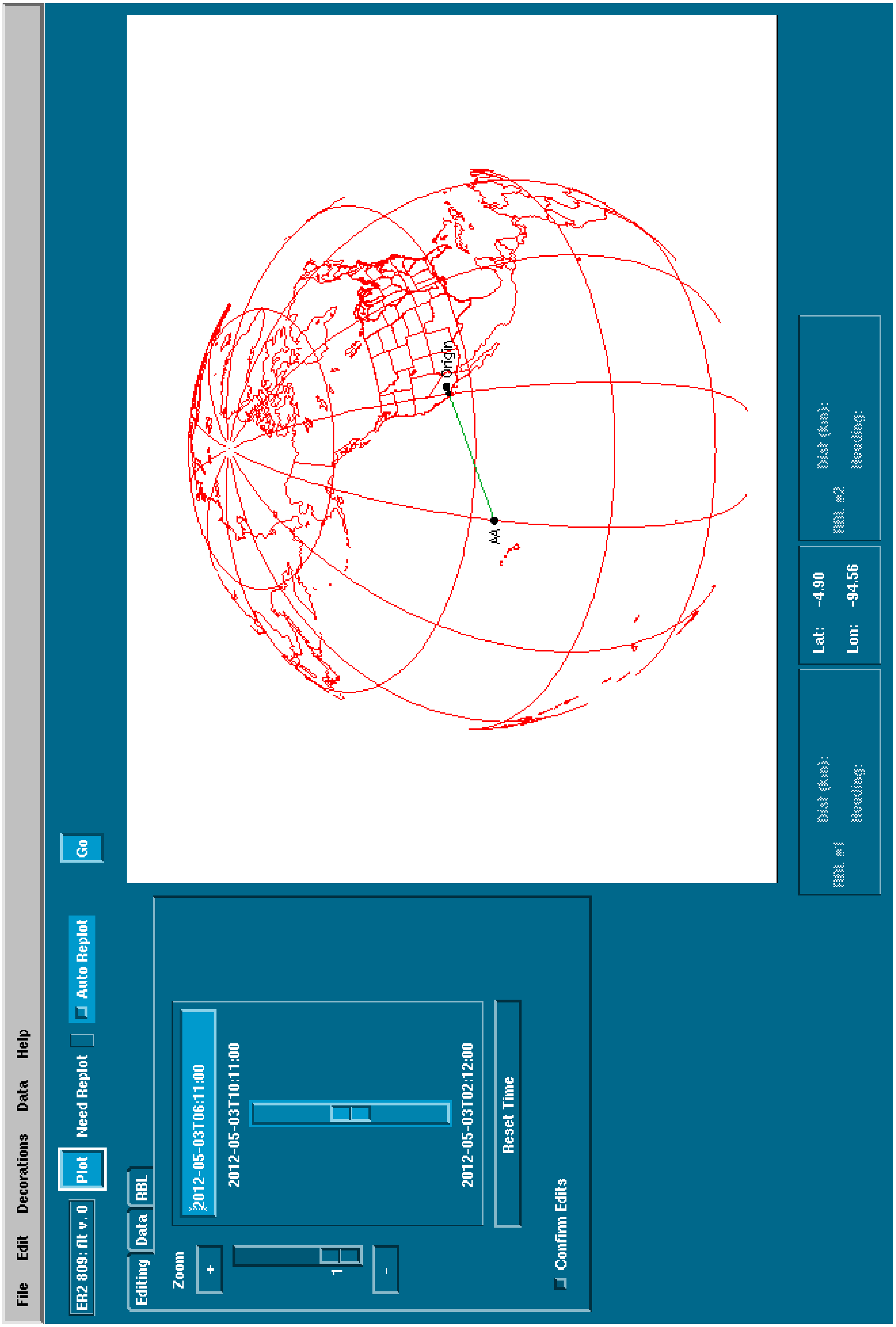

Figure 2.11: The EditMap Display Widget

Finally, the *Go* button works the same as the one in the bottom right of the Flight Plan widget: press it to have your edits take effect.

When you first bring up the map, it is centered over the middle of the flight and zoomed out to view the whole globe. You can center the map over a spot of your own choosing by moving the mouse cursor over the spot and then clicking the right mouse button once while holding down the control ("Ctrl") key. For zooming, you can use the *Zoom* control to the left; either click on the + button or the - button, or move the slider to a value of your choosing (higher numbers are zoomed in). Alternatively, you can zoom in and out by turning your mouse wheel, if your mouse has a wheel. Practice zooming in around the middle of the flight track.

Move your mouse pointer over the map while watching the lower right corner of the EditMap display. The longitude and latitude of the pointer are shown in the readout, so you can always know where you are pointing.

To move a defined location, click on it with the left mouse button, then drag it to a new place. You can create a new location by double-*right*-clicking the place on the map where you want the point to appear. If you single-click on a location, highlighting it, you can do fine-scale changes of the location by using the cursor keys on your keyboard. Pressing either the "d" key or the "Delete" key will delete any highlighted location. (Be careful, though, because any maneuvers that reference the deleted location will still be in the plan and will cause an error when you next press *Go*.)

Take some time now to add four new locations to the map. (Be sure to use the right button; double-clickin on the left button beings up a rubber-band line, which we will cover momentarily. For now, if you double-left-click instead of double-right clicking, simply press the "q" key to make the yellow rubber-band line go away.) Left-click and drag each location around the map. Next, click on one of these locations to highlight it. Then move the mouse cursor over another location and single-left-click on that one. As this location becomes highlighted, the other point is no longer highlighted. You can actually highlight more than one location at a time: move back to the first location and hold the Shift key down while you single-left-click on it. You will see it become highlighted in a slightly darker shade of yellow than the other point, which remains highlighted in the brighter color. Now use the left mouse button to drag the brightly-highlighted location somewhere. You will see both locations move, keeping their relation to each other. The "Delete" key, by the way, will delete all highlighted locations, not just first main one. Here is another trick with highlighted points that you might find useful: move each of your new points so that they are all very close to the flight track between “Origin” and “AA”. Then highlight them all. Then press the “s” key on your keyboard. (The “s” stands for “snap”.) The highlighted locations will shift slightly so that they will all lie exactly on the flight track, if they were close enough to the track to start with. You will get a red error window informing you if any highlighted locations were too far away form the track to be snapped to it.

Sometimes the software is a little finicky about where you click. Try to keep your hand very still when you click to highlight, especially with multiple locations, so that the software does not think you are trying to drag anything. It can be very easy to lose your highlighting otherwise.

Now delete the new locations you just added, to clear the map for a new editing procedure. So far, you have learne dhow to add new defined locations to the plan. But those locations are now actually part of the plan. To actually add new legs to the flight plan, you will use the rubber-band line. Move the mouse cursor somewhere the middle of the long leg our to location “AA” and double-left-click. Two yellow lines will appear, one leading from a point near “Origin” to your mouse cursor, and the other leading from your mouse cursor to “AA”. Use the left mouse button to drag the kink in the rubber-band line around the map. Notice how the yellow lines move with the point being dragged. Notice also that the *RBL #1* and *RBL #2* displays at the bottom of the map are updated with the distances and bearings between the two oend way points and your moving mid-point.

Put the cursor where you want it, and then press the “a” key on your keyboard to add a new maneuver. The flight track now goes from the first point to your new location (which is created for the occasion) and then on to “AA”. Yuo do not even need to press “a”, actually; simply double-left-click on a new point, and the current rubber-band line will be turned into a new maneuver added to the flight plan and a new rubber-band line will be started. In this way, you can click-click-click on the map to create nearly a whole plan. (Note, however, that vertical maneuvers cannot be added this way, so takeoffs and landings will still need to be added to the flight plan panel.

When you first double-left-click to start a rubber-band line, the software tries to figure out where in the flight plan to insert the new maneuver, based on which locations are closest to your mouse cursor. Sometimes it guesses wrong, but you can fix that easily. While the rubber-band line is on the map, press the “f” key to step forward in the plan, or the “b” key to step backward.

When you have the points that you want bracketing the rubber-band line, then you can proceed with your editing.

As noted above, you can finish either by pressing the “q” key (“d” will also work) to quit, or the “a” key to add the current line and then stop. Note, by the way, that you can change the colors in which the highlighted lcoations and the rubber band lines appear, by going to the *RBL* tab in the controls to the left of the map.

You have probably noticed that every time you add a location, delete a location, move a location, or add a new maneuver, the software will ask you if you really want to do that. If you find those confirmation notices annoying, you can turn them off by toggling the *Confirm Edits* button to the left of the map.

You can also measure the great-circle distance between any two spots on the map. Move the mouse pointer to a starting spot, then hold the right mouse button down as you drag the pointer to the ending spot. When you release the button, a small window appears that shows the distance and bearing from the starting point to the ending point. If you need to estimate the time it would take the aircraft to travel that distance, enter the altitude in the blank and press your ENTER key; the time (in minutes) will appear. By default the units are nautical miles (nmi) and thousands of feet (kft); you can switch to kilometers by unchecking the *Nav units* box. Click *OK* to close the window.

We are done changing the flight plan for a moment, but there is more that you need to learn about the map displays.

The map can show two kinds of things: decorations and data. Every map has at least two decorations: the map itself and the flight track, and each has attributes that can be set, so that they look just as you want them.

Go to the top menu bar, under *Edit*, and click on *Map Spec*. A Map Spec widget appears as in Figure 2.12. Here, you can set the map center and zoom with more precision than with the mouse movements you were using before. (Note, thogh, that for historical reasons here larger zoom factors mean the mpa is more zoomed *out*.) You can also change how longitude-latitude graticule and continents are drawn. Try changing the latitude-longitude spacing to 5 degrees, the color to “lightskyblue”, the line style to dashed, and labels to “every one” (set *Label Skip* to 1). Make the continents blue, with lines of thickness 2.

Before you click on *OK*, take a look at the *Order* entry blank. This contains a number. Every decoration and data to be plotted has an order

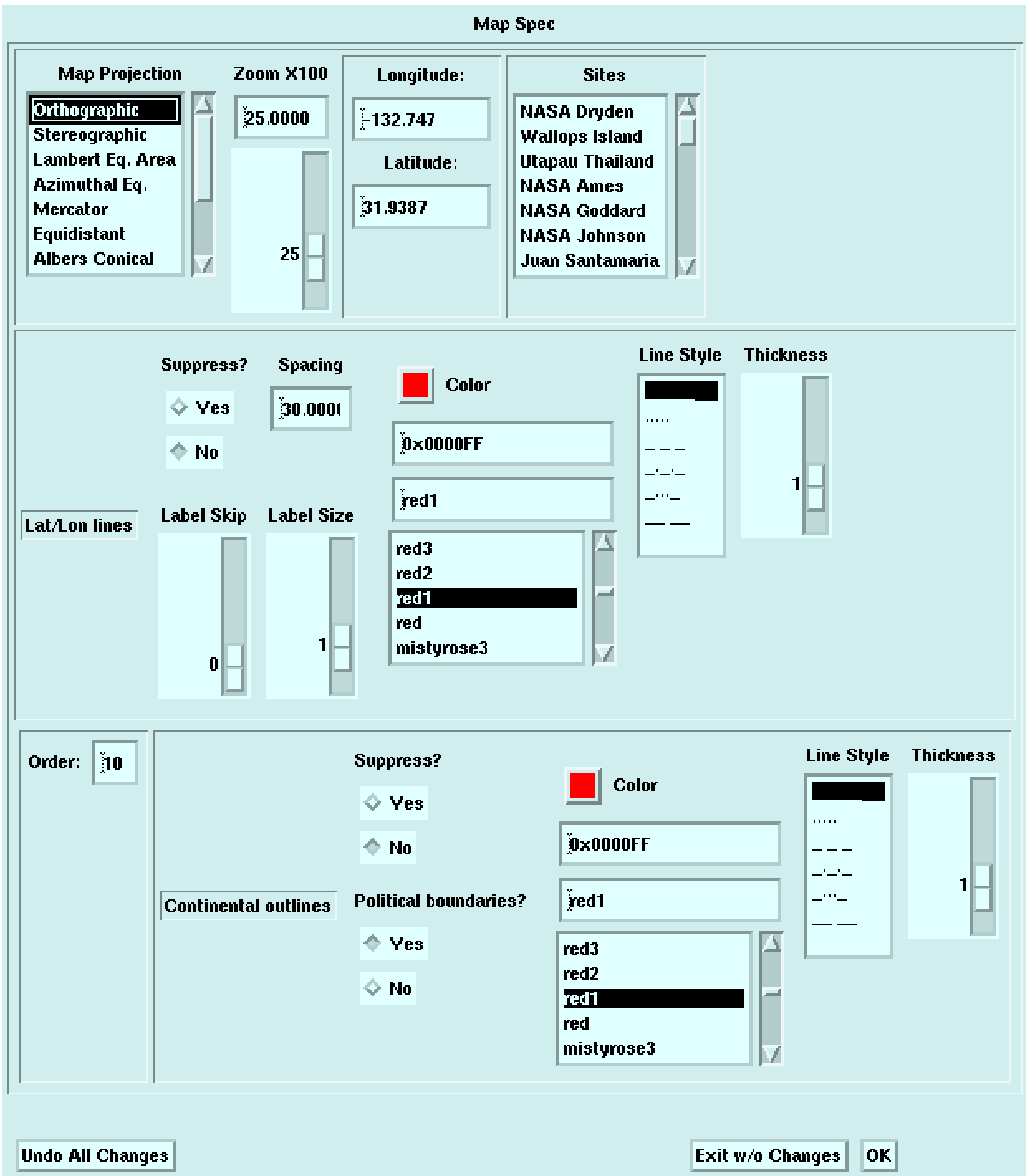

Figure 2.12: The Map Spec widget

number. When the *Plot* button is pressed, and the map is re-plotted, items with lower numbers are plotted first. In this way, you can layer the various plot decorations and data plots (e.g., contours), one on top of another, to enhance the visibility of the ones you need most.

Once you have clicked on *OK* here, the map in the map display refreshes automatically (because its *Auto Replot* button is set).

Now let's change how the flight track is displayed. Go to the top menu bar, under *Edit*, and click on *Flight Track Spec*. A Flight Track Spec widget appears as in Figure 2.13. Set the *Line Thickness* to 3. If you want arrows on the track to show the direction in which the aircraft travels, then set the arrow spacing to something other than 0, and set the arrow size as well. Ordinarily, the line thickness and the arrows apply to the entire flight track, but you can restrict them by specifiying the highlighting center and width, in hours. Setting the highlighting center time will restrict the outer line and the arrows to be displayed only over an interval corresponding to the highlighting width centered on the highlighting center time. If the center time is negative, then the current time of the plot is used (this is useful when making animated plots). A width of zero or less will cause the entire track to be highlighted; this is the default.

Other tabs in the Flight Track Spec widget let you change other aspects of the flight track beside the track lines. Under *Key Pnts*, set the *Key pnt size* to 4; this will enlarge the points at which something significant happens in the track. Under *Locs*, set the *Location Size* to 3, *Label Background* to "Yes", and then *Lab. Bkg. color* to "green". (This last one will cause each location label in the map to be written in a green background box.)

(You can ignore the *Anim. Symb.* tab, since the EditMap display does not do animation.)

If you like, you can also have this decoration display arrows on its map display, to clarify the direction of travel. The size and the spacing of the arrowheads are set by sliders. A spacing of 0 (the default setting) results in no arrows being draw.

Note that the Flight Track Spec widget has no *order* control. That is because the flight track is always drawn last, so that it is always visible on top of everything else. Now click on *OK* to see the result of your changes.

Note that the flight track is now thick enough that both its inner and outer colors show up.

We can add new decorations to the map. Go to the *Decorations* menu in the top menu bar and click on *FIRs*. This is a plot decoration that shows the

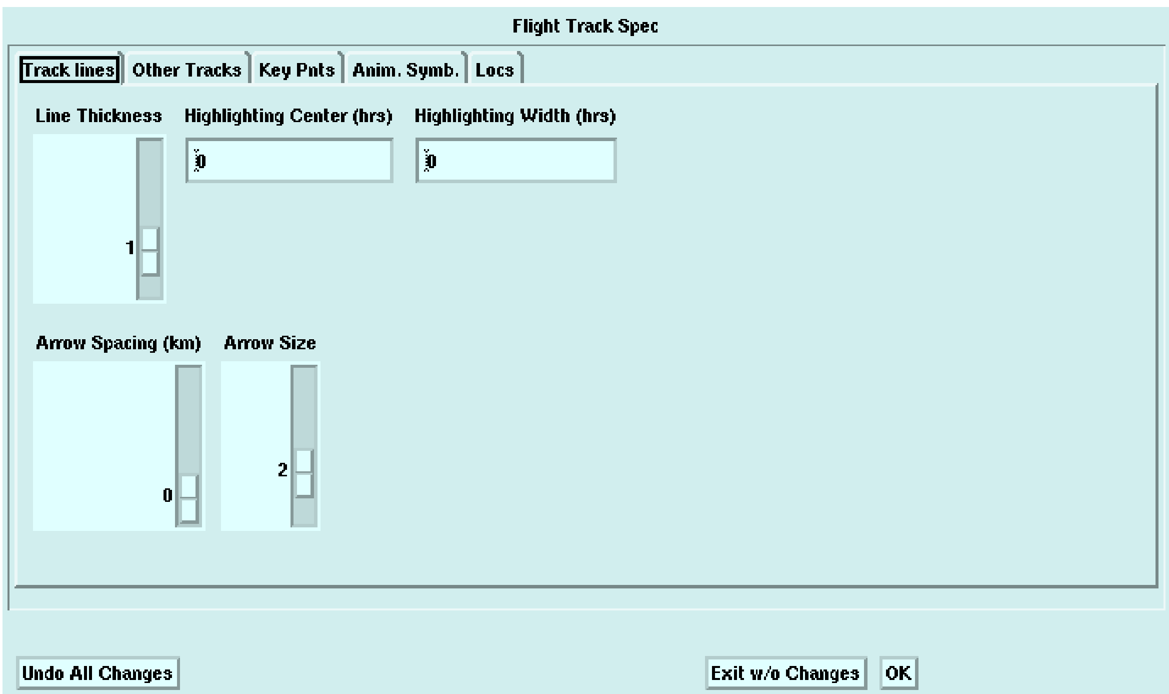

Figure 2.13: The Flight Track Spec widget

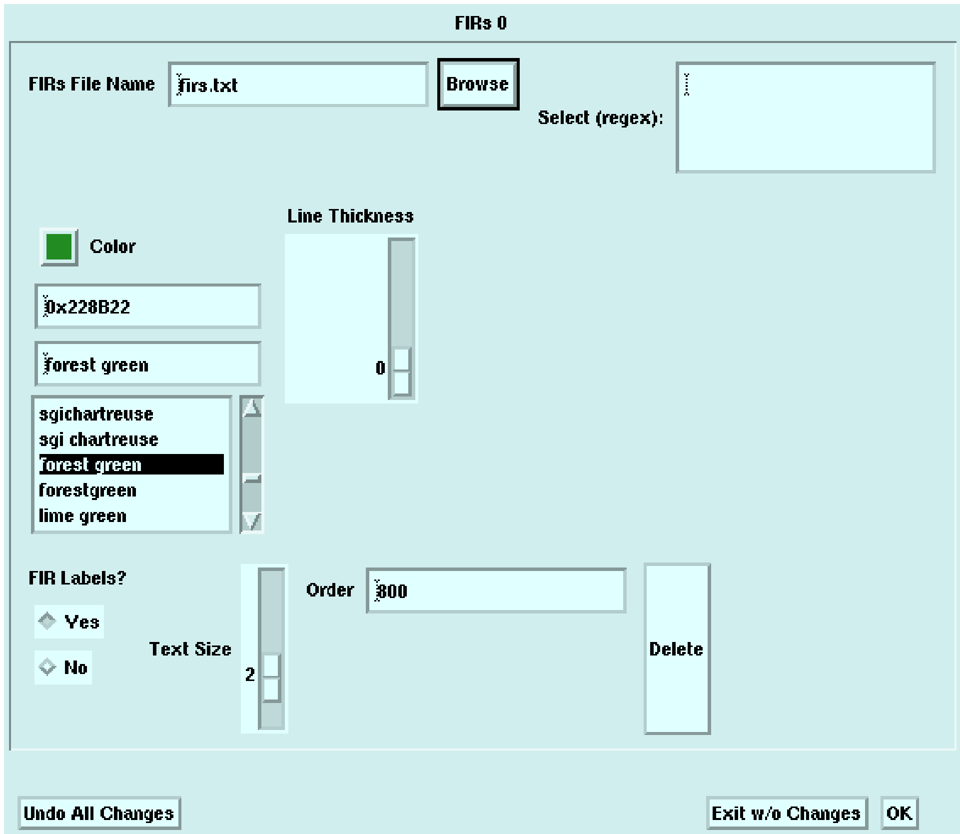

Figure 2.14: The FIRs Spec widget

Flight Information Regions defined by civil aviation authorities. You get a chance to set how the boundaries of these regions are displayed. For now, simply click on the *OK* button. You may need to zoom out a little on the map to see the FIRs.

Now let's go back and change how the FIRs are drawn. We will not go back to the *Decorations* menu, since that is only for *new* decorations. Instead, go to the *Edit* menu, where you will see a new items, *FIRs*. Remember this: you go to *Decorations* and *Data* to add new things; you go to *Edit* to change the things that you already have.

The FIRs widget is seen in Fig 2.14. Change the *Text Size* of the labels to 4. In the *Select (regex)* box near the top, type in "OAKLAND".

When you click *OK* and the map display refreshes, you will see that only two FIRs now appear, both containing the name "OAKLAND". You can use the *Select* box to type in as many strings as you like, one per line. These will be treated as regular expressions to match against the FIRs' names. In this way, you can draw only the FIRs that you want to see. And by bringing up addition FIRs decorations, and setting their FIRS widget controls differently, you can display different groups of FIRs in different colors.

You can play around with different data displays to show such things as landmark locations, satellite overpasses, great circle lines, swaths from on-board instruments, and range rings. You can even read in images from local files or from the world-wide web, and if they are in straight rectangular longitude-latitude coordinates, they can be mapped onto the display along with your other plot decorations

If you have local data files in the "/science system" used by NASA Goddard's Atmospheric Chemistry and Dynamics Lab, you can display those data on the map as well. Go to the *Data* menu on the top menu bar, and select *DF Met Data*. We will defer the description of the controls until later, so just click *GDAS* in the menu in the lower left corner, and then click *OK*. If you have the data on your system, the software will take a few moments to read the data and plot them. By default, the temperature field at 50 mb is displayed at the time of the middle of the flight. The data are interpolated in time, but of course you can change this. If the data are not present or accessible on your system, then you will get a "No Data" notation on the plot; no harm done.

Note the time slider control in the *Editing* to the left of the map. By default, this is set to the takeoff time plus half the nominal flight duration, and that is the time to which the meteorological data will be interpolated for display. By changing the time slider control (either by sliding the control or by typing in a time stamp at the top and pressing ENTER), you can view the same field or fields at a time of your choosing.

You can bring up multiple EditMap Display widgets at the same time, each potentially displaying a different combination of decorations and/or data, with different map center and zoom settings.

Tip:

If the map display is too small or too big, you can re-size it, and the plotting area will grow or shrink accordingly. You can do this with most displays in the flight planner. The plot's aspect ratio will remain the same, though, and the surrounding controls may shift around oddly.

2.6 Old-Style Map Display

If you hve used the flight planner software in the past, you may have learned how to use a different kind of map display. That display is still available by selecting the *Map w/ Flt Edit* control fromthe Flight Plan panel. Using that older-style map display is described in this section.

The Map Display widget that comes up should look something like Fig 2.15.

Before we start fiddling with the flight plan, note the controls along the top row of the Map Display widget. The *Plot* button triggers a re-plot of the display when clicked. To the right of this is a *Need Replot* indicator; when this has an asterisk, the plot is out of date, and you should click on *Plot* button. The next control is *Auto Replot*; this toggles whether the plot is automatically re-plotted (as if you had clicked on the *Plot* button) whenever the *Need Replot* indicator shows an asterisk. By default, this is on. But if you need to make a number of changes, and you don't want the plot take the time to refresh after each change, then you should turn this off momentarily.

The next three buttons determine which of three modes the display operates in. The button with the "M" is *Maneuver Mode*, which lets you add new maneuvers to the plan by clicking on the map. The circle with the dot in the center is the *Location Mode*, which lets you create and move defined locations. The crossed arrows mark the *pan-and-zoom mode* button, which lets you re-center and zoom the map. The button that is lit green shows the mode that the display is in. Click on another button to change to that button's mode.

In pan-and-zoom mode, you can left-click anywhere on the map, and that will become the new center of the map. If you hold down the right mouse button and drag the mouse pointer from the lower-left to the upper-right, the display zooms in on the map to give you a more detailed view. To zoom out, hold the right mouse button down and move the pointer in the opposite direction. Practice zooming in around the middle of the flight track.

Next, press the *location mode* button to switch to that mode. Use the left mouse button to grab the "AA" location and drag it a little to the south and east. (Note: the point does not actually move yet.) A notification panel asks if you really want to redefine the point's location. Click *Yes*. Now move the mouse pointer to an empty part of the map and double-left-click to create a new defined location. Again, a notification panel appears for confirmation. Click *Yes*, and the new point appears on the map. If you look at the defined location table on the Flight Plan widget, you will see the new point, as well as the new location for the "AA" point. In location mode, you can also measure the great-circle distance between any two spots on the map. Move the mouse pointer to a starting spot, then hold the right mouse button down

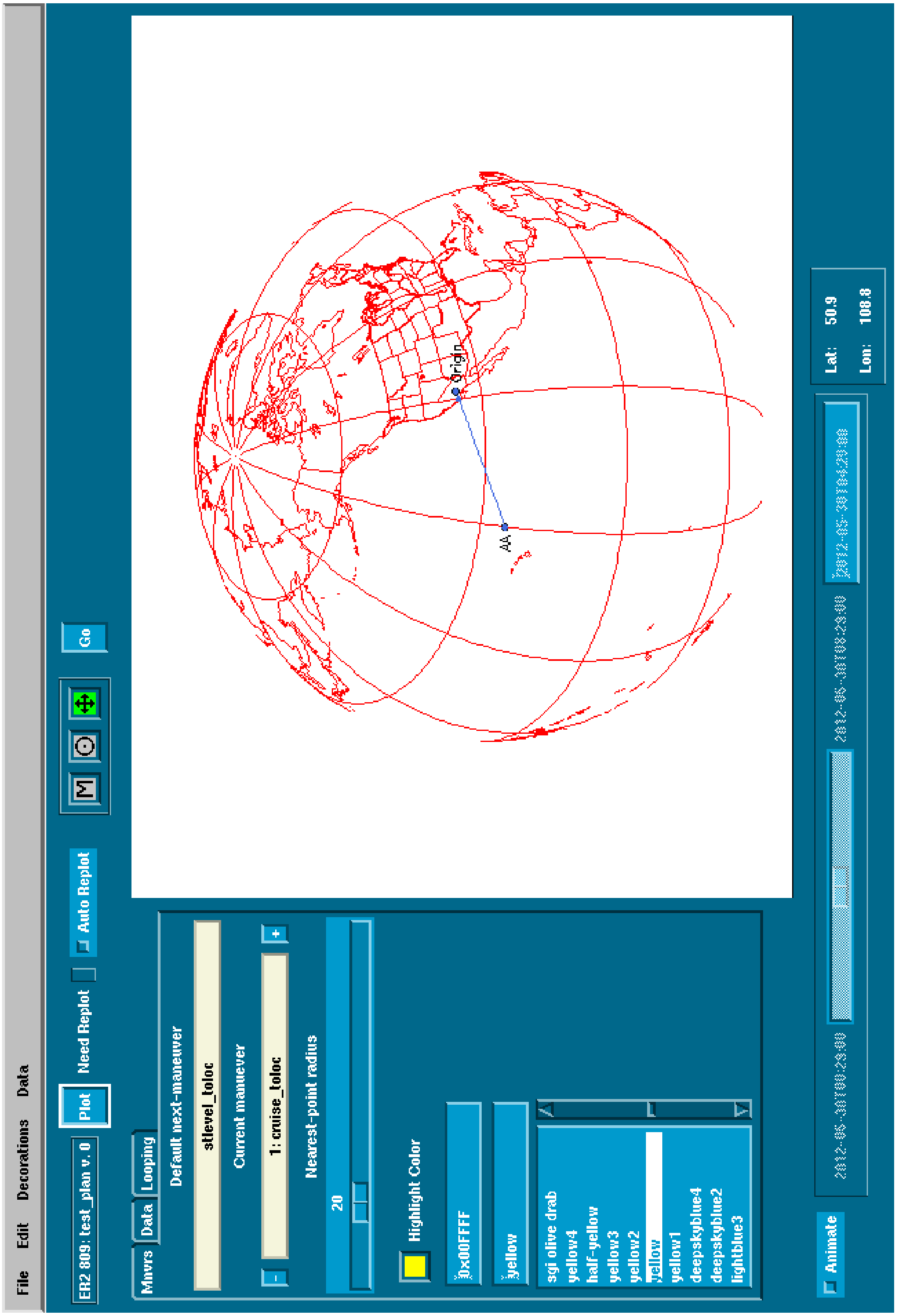

Figure 2.15: The Map Display Widget

as you drag the pointer to the ending spot. When you release the button, a small window appears that shows the distance and bearing from the starting point to the ending point. If you need to estimate the time it would take the aircraft to travel that distance, enter the altitude in the blank and press the ENTER key; the time (in minutes) will appear. By default the units are nautical miles (nmi) and thousands of feet (kft); you can switch to kilometers by unchecking the *Nav units* box. Click *OK* to close the window.

Next, click on the *maneuver mode* button to switch to that mode. In this mode, left-clicks and left-double-clicks work the same as in location mode, so that you can create and move defined locations. But right-clicks let you add new maneuvers. What kind of maneuvers? Click on the *Default next-maneuver* button and select the *Cruise climb to a given location* maneuver from the Choose Flight Maneuver widget that appears. New maneuvers added by right-clicking will be *cruise_toloc* maneuvers. Where in the plan will a new maneuver be placed? You will note that the line to "AA" is highlighted yellow. If you look back at the list of maneuvers in the Flight Plan, you will see that the indicator light on the second maneuver is yellow; that means that this maneuver is currently active. It is the active maneuver on the map that is highlighted in yellow when you are in maneuver mode in the Map Display. (Note that you can change the map's highlighting color.)

Tip:

You can choose the Map instead of Map w/ Flt Editing in the View menu, and the map display will have none of the maneuver mode controls.

Move the mouse pointer over the "P2" point and single-right-click on it. A New Maneuver notification will appear; click *OK* to confirm, and a new *cruise_toloc* maneuver to location "P2" will be added to the plan. Now move the mouse pointer to an area of open space somewhere east of "P2" and right-click again. Again, click *OK* on the New Maneuver notification that appears. This time, not only is a new maneuver created, but a new defined location is created for the maneuver. If you right-click on an existing location in maneuver mode, the maneuver uses that point, and if you right-click away from any defined location, a new one is defined for the new maneuver to use. How far away from a defined location do you have to be before a new location is created? That is set by the *Nearest-point radius* slider control.

We are done changing the flight plan for a moment, so click on the *pan-and-zoom mode* button (the one with the arrows).

Move your mouse pointer over the map while watching the lower right corner of the map display. The longitude and latitude of the pointer are shown in the readout, so you can always know where you are pointing.

This kind of map display offers the same decorations and data displays as the EditMap described above. But one thing it can do that the EditMap does not, is animation.

Go to the top menu bar, under *Edit*, and click on *Flight Track Spec*. Set the line thickness as desired. Go to the *Anim. Symb.* tab and set the *A/C sym size* and *A/C sym color* to 4 and "red", respectively. This determines how the aircraft symbol appears in animated displays. which we will get to momentarily. Now click on *OK* to see the result of your changes.

Note that the flight track is now thick enough that both its inner and outer colors show up. Add a data plot as you did with the EditMap display.

Now find the *Animate* button near the bottom left corner of the map display widget. Click it to turn the map into an animated display. Wait patiently while the each time frame gets re-drawn. Then note that the time slider on the bottom row has been enabled. Use your mouse to grab the time slider and move it back and forth. Watch the display as a large red dot (we set the *A/C Symbol Color* and *A/C Symbol Size* above, remember) moves along the flight track; this dot represents the aircraft. If you are displaying data, you can see the time-interpolated meteorological fields evolving as the aircraft flies along.

You can make the display animation loop on its own by clicking on the *Looping* tab, then sliding the *Looping Speed* control. The higher the number, the faster the loop goes. Setting it to 0 stops the loop, as does grabbing the time slider.

By default, animation frames are spaced one hour apart, as a compromise between the time it takes to compose all the frames (fewer frames is quicker), and the smoothness of the animation (more frames is smoother). Thus the motion may look a little jumpy, but you can change that in the *Anim Time Res* item under the *Edit* menu at the top menu bar.)

You can bring up as many Map Display widgets as you want. They do not interfere with each other or with the EditMap Display widgets.

2.7 Curtain Plot Display

Now that we have a map of the flight track, let's move on to a different kind of display: the curtain. A curtain display is a time-versus-altitude plot, where the time is the time-of-flight of the aircraft and thus corresponds to a set of longitudes and latitudes of the aircraft position long the flight. (See Figure 2.16.) Think of a curtain hanging vertically; its shadow on the floor traces out a horizontal path along the floor, like the flight track of

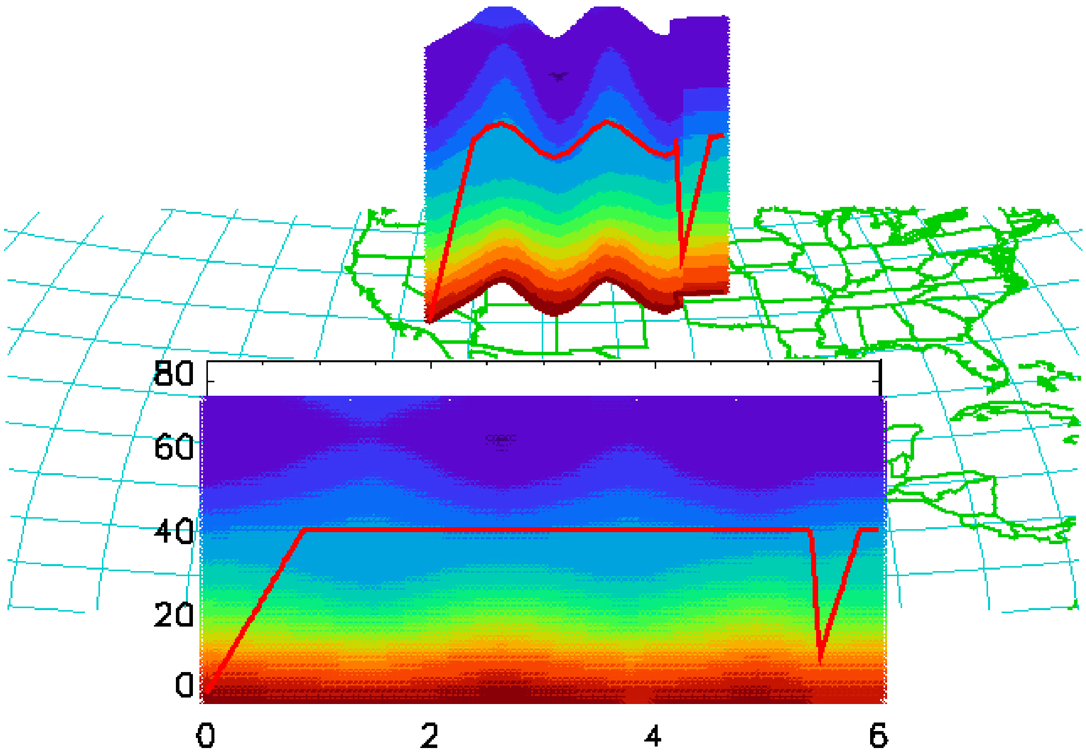

Figure 2.16: A Curtain

an aircraft. But at each point along that path, you have a bit of curtain extending vertically.

To bring up a Curtain Plot widget, go to the *View* menu on the top menu bar of the Flight Plan widget, and select *Curtain*. The new display will appear as in Figure 2.17. Many of the controls along the top and bottom are similar to those for the Map Display. But there are no mode buttons, and no maneuver mode controls, since the curtain plot is only for display and not for flight track editing. As you move your mouse pointer through the plot, the readout in the lower right corner displays the time, longitude, latitude, and altitude of the pointer location.

If you go to the top menu bar, select *Edit*, and then select *Curtain Spec*, you can control how the curtain plot looks. The control appears as in Figure 2.18. You can limit the extent of the plot either vertically (with the Pressure *Floor*

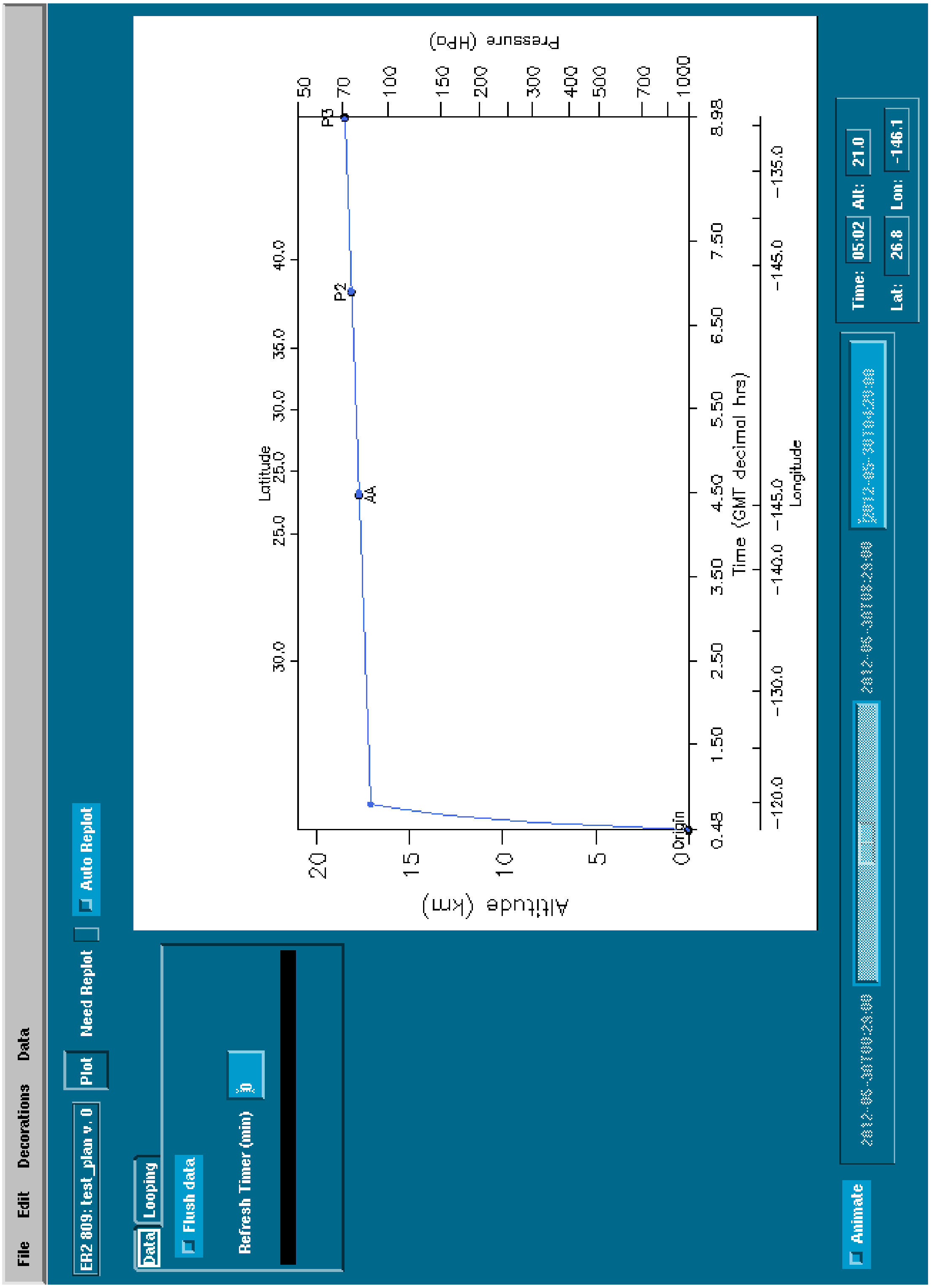

Figure 2.17: The Curtain Plot widget

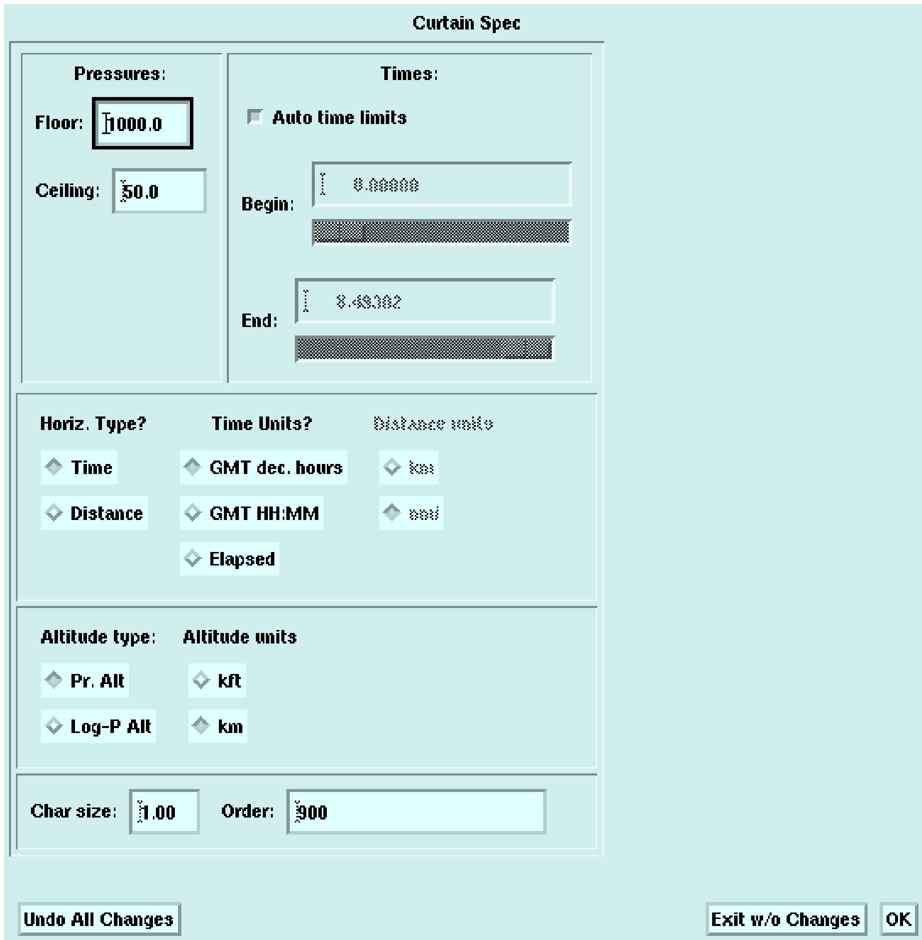

Figure 2.18: The Curtain Spec widget

and *Ceiling* controls), or horizontally (with the *Times Begin* and *End* controls, if the *Auto time limits* button has been disengaged.)

You can choose how the x-axis of the plot appears. The default axis is time, but you can choose distance-along-flight-track instead. You can choose to have the time axis shown as decimal hours in GMT, or "hh:mm" format in GMT, or hours elapsed since takeoff.

Likewise, you can choose how the y-axis appears. The most useful control here is *Altitude Units*, either *kft* or *km*. Click on *kft*, then on the *OK* button. The plot's altitudes are now in aviation-preferred units.

There are decorations you can apply to the curtain plot—although fewer than there are for the map display. You can also display meteorological data as vertical profiles interpolated in space and time to the flight curtain.

And as in the map display, the curtain plot can be animated.

2.8 List Display

Now go back to the Flight Plan widget's top menu bar, select *View*, and then *Tabular Listing*. This will bring up a Flight Tabular Display for your flight plan. This is a text report, not graphical, that can display various sorts of useful information. As seen in Figure 2.19, the controls are at the top, and the displayed information is in the bottom portion of the panel. The *Need Refresh*, *Auto Refresh*, and *Refresh* buttons work like the *Need Replot*, *Auto Update*, and *Plot* buttons in the map and curtain display widgets.

There is a button, *Summary*, to toggle the display of summary information (takeoff time, flight duration and distance flown). Similarly, *Notes* toggles the display of the Note you entered into the Flight Plan widget. You can display the table of defined locations, and if you do you can choose the format in which their longitudes and latitudes are expressed. (Different audiences will prefer to see them in different formats.)

By default, the tabular data will be displayed for each point along the flight track, as simulated. The time resolution is typically 5 minutes (but can be changed by you). However, if you toggle the *Key points only?* button, only significant key points along the flight are presented. These include way points, turns, and sudden changes in altitude. You can also choose to label every point that is displayed, in case such labels are needed for reference in discussions.

Let's begin to construct the table. Click on the *Add Column* button at the top to get a menu, then click on the menu item that you want displayed. Every time you select a new quantity from *Add Column*, a new column appears in the listing.

Let's start with *UTC Date & Time*. Next, add *Latitude (deg-min)* and then *Longitude (deg-min)*; the latitude and longitude of each point appears in the degrees-minutes format. Add *altitude (ft)* to see the aircraft altitude in feet. *Location Name* is also a useful thing to add; if a point along the flight path lies within a certain distance (set by *Horiz. Tol (km)*) from a defined location, that location will be listed.

As with most of the displays, you can re-size the display widget if your

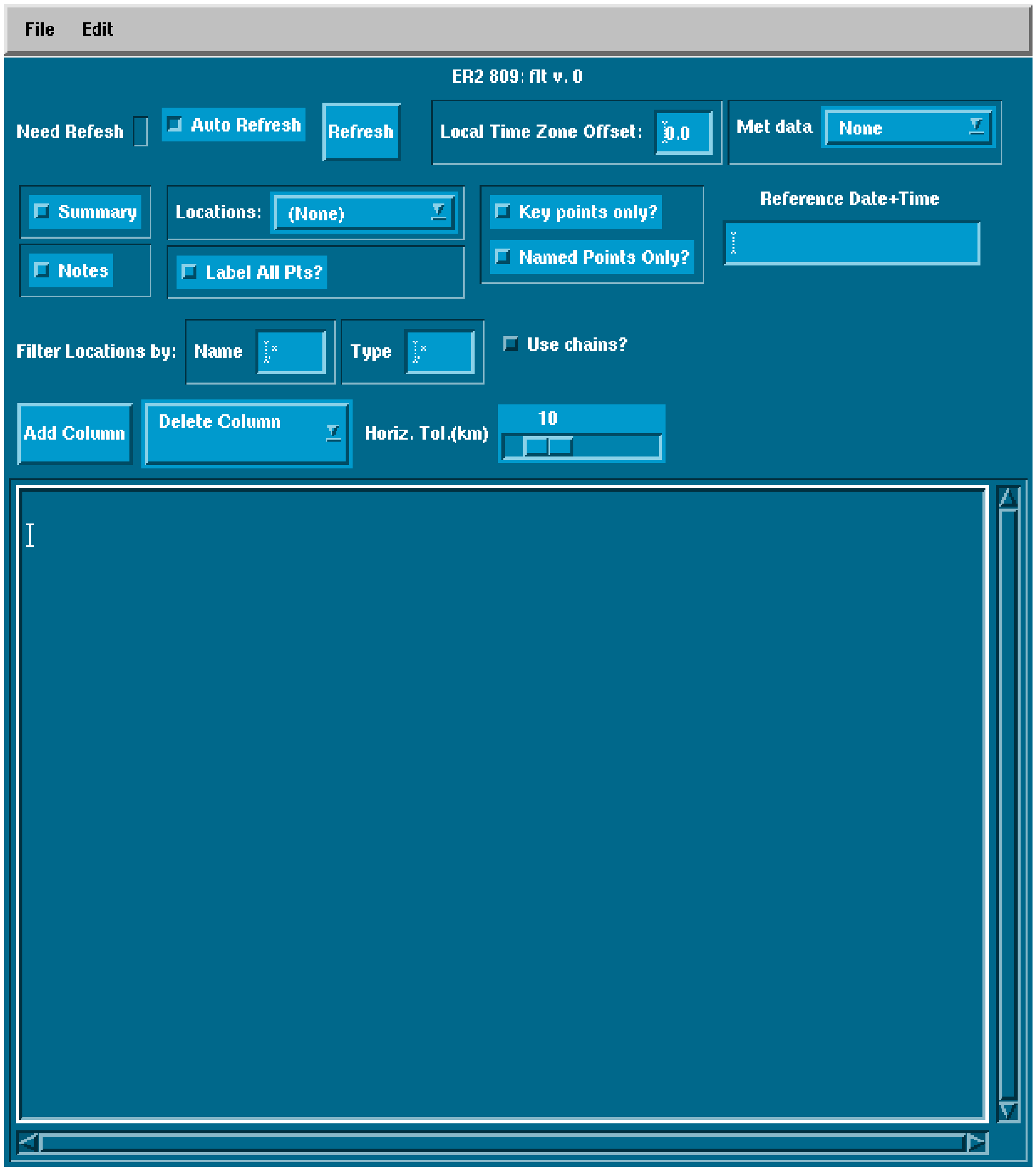

Figure 2.19: The Flight Tabular Display widget

desktop environment permits it, so that you can see more of the list at a time.

To delete a column of information, use the *Delete Column* button at the top.

One of the columns you can select for display is *Local Time*. For that, you will need to specify the offset between local time and UTC. The *Local Time Zone Offset* control does that. For Edwards Air Force Base (in the Pacific time zone), the difference is -8 (hours) for standard time, -7 when daylight savings time is in effect. Enter the right number. There are also some columns that give the time displacement from an arbitrary reference time. You can specify that reference time in *Reference Date+Time*, in "yyyy-mm-ddThh:mm:ss" format.

Several of the columns you can select (*Met. Temp. (C)*, for example) require meteorological data to be read in and interpolated to the simulated flight track. You can choose one of several sources of such data from the *Met data* control in the top right corner. Otherwise, with no data available those numbers will be given as rows of dashes.

With three displays all set up, let's now move on to finish editing the flight plan.

2.9 Finishing a Flight Plan and Saving Your Work

Go back to the Flight Plan control panel/widget. As you can see from the map and the curtain displays, we still have not added a landing to the flight plan, so do that now. Scroll down the list of maneuvers until you get to the last one, and click on its downward arrow button to add a new maneuver after it.

The maneuver you want to add is from the *landing* group, *Land at a given location*. When the landing_toloc editing widget appears, fill in "Origin" for the required LOC parameter, and leave ALT as 0 (unless you want to be really accurate and use the altitude of the Dryden runway). Then click on *OK*.

Tip: *Changing the location name in the location table changes all occurrences of that name in all maneuvers' parameters, automatically.*

Now click on the *Go* button on the Flight Plan widget. Note that every display which has been set to auto-replot or auto-refresh will now refresh itself. For animated plots showing meteorological fields, this may take some

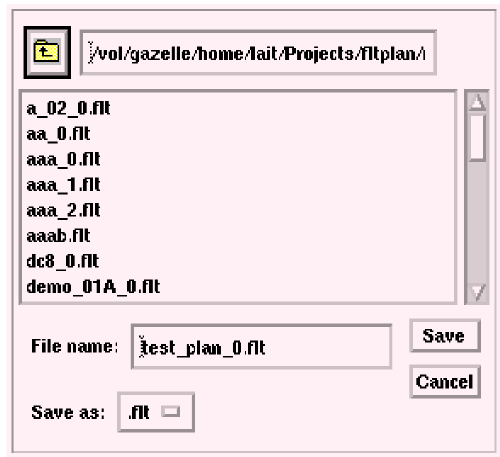

Figure 2.20: The Save Plan File Selection Widget

time. So either turn off auto-replot for those displays, or turn off animation, or avoid clicking the *go* button until you have finished making changes to the flight plan.

At this point, we have a complete flight plan, nicely displayed in plots and text. The next thing to do is to save your work, so that you don't have to re-create everything from scratch the next time you run the flight planner. The plan itself is separate from the displays which show it, so the two are saved to different files.

Let's save the plan first. Go to the *File* on the Flight Plan widget, and click on *Save Plan*. A file selection menu will appear, as in Figure 2.20 The default file name is built from the flight *Name* and *Version* on the *Basic Specs* tab of the Flight Plan widget. You can change it to anything you like, but the file name should end in ".flt". Click on the *Save* button to save, or *Cancel* to cancel and return to the Flight Plan widget.

Tip:

Using Save Basic Defaults from the File menu of a display will save some of the (non-flight-specific) configuration settings to a special default file that will be loaded whenever you bring up that kind of display.

Similarly, you can save your current display configuration—all settings of all displays that are currently up—by clicking on the *Save Display Config* entry on the *File* menu. Alternatively, you can save each display to its own individual configuration file using the *File* menu on each display widget.

Once you have saved your plan and your display configuration, close the plan by selecting *Close this plan* from the *File* menu of the Flight Plan widget. An orange warning notification window will appear asking if you really want to close it. Click on *Yes*. The Flight Plan widget and all of its display widgets

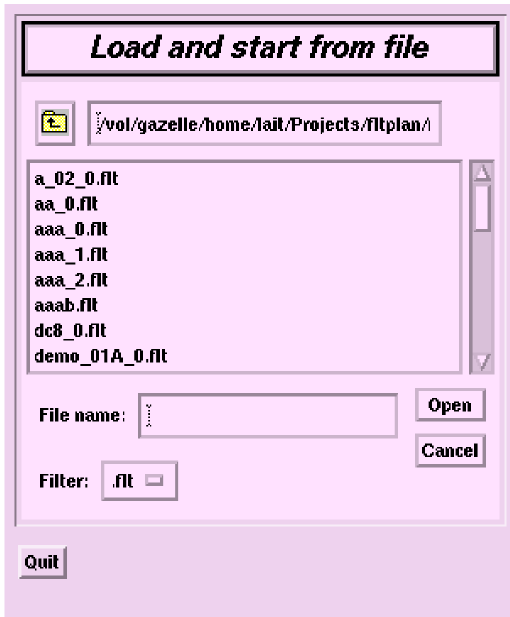

Figure 2.21: The Load Plan File Selection Widget

will disappear.

Tip:

Save early, and save often. The flight planner is not without bugs, and neither is the IDL language interpreter. You do not want to work up a complicated flight plan and display setup, only to have the software crash and leave you with nothing for your hours of work.

2.10 Loading the Flight Plan and Its Configuration Back In

The only widget you have left now is the Entry widget. Click on *File* in its top menu bar, then select *Open Flight Plan*. A file selection widget will appear as in Figure 2.21. find the plan that you just saved and click on *Open*.

The Flight Plan widget for the flight will appear. This widget always starts up in the *Basic Specs* tab, to give you a chance to change the version or possibly the name before you move to the *Editing* tab and begin editing the plan.

Click on the *File* menu on the top menu bar here, and select *Load Display Config*. Another file selection widget will appear, with the default configuration file name already loaded. Since we saved our display configuration with the default name, you should just have to click on the *Open* button. The same three displays that you had before should now reappear, with all of

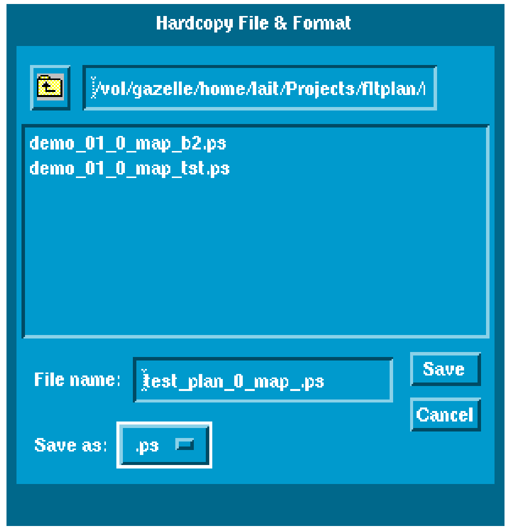

Figure 2.22: The Hardcopy File & Format widget

their settings.

If you wanted to, you could click on *Load Display Config*, load the same file a second time, and get duplicates of the same three displays. Loading a display configuration always adds new displays; it does not replace displays that are already up.

At this point, we have a flight plan worked up, along with a set of plots. The plan and its display configuration have also been saved, so that you can come back to work on it later. Now it is time to communicate the new flight plan to other people.

2.11 Making Hardcopy

Any individual display may be exported to a file by clicking on *Export this display* from its *File* menu. A Hardcopy File & format widget like that in figure 2.22 will appear to let you choose the file name and its format.

Graphical plot displays such as the map and curtain may be exported to any of three formats: PostScript, encapsulated PostScript, PNG image format, and JPEG image format. PNG is good for embedding in web pages and rough documents. PostScript is fine for sending directly to a printer. But for better quality plots that you can include in a word processing document, encapsulated PostScript is best.

Similarly, you can export text displays such as the Tabular Display to any of three formats: plain text (ASCII), rich-text format (RTF), and comma-separated-value (CSV) format. Text is best if the output is to be read by other computer analysis programs. RTF gives you a nicely-formatted table to pull into your favorite word processing program. And CSV format can be loaded into your favorite spreadsheet software.

Please note one quirk about the Hardcopy File & Format widget: The *Save as* menu sets only the kinds of files that are displayed in the directory listing above it. It does *not* change the type in the name in the *File name:* entry blank. But that is the part that counts. Thus to change the file format you are saving from the default, you need to change the end of the file name to ".ps", ".eps", ".png", or ".jpg" for graphics, to ".txt", ".rtf", or ".csv" for text.

If you have many displays up at the same time, you probably want to export all of them to hardcopy files at the same time, instead of tediously going to the *File* menu of each display one by one. You can do this. In the *File* menu of the Flight Plan widget, click on *Export this flight's displays*. A signal will be sent to each of the displays to export itself to a file. How do you set the file names and types? The name is generated automatically (based on the plan name and version), and the default type of PostScript is used. You can change this for any display by clicking on the *Edit* menu of its top menu bar, then clicking on *Default Hardcopy Name*. You can set part of the file name, and you can set the file format. (These settings are saved in the display configuration files along with all other settings.)

You can also export your flight plan to a KML file, suitable for loading into Google Earth and other similar applications. From the *File* menu of the Flight Plan widget, select *Export Plan to KML*. A new widget will appear as in Figure 2.23.

You can have all the defined locations displayed as push-pin symbols by setting the *Locations?* button. You can highlight points along the flight path as time progresses (using the *Time-varying?* button). You can have the flight path right on the surface of the earth, or you can have it be three-dimensional in either meters (for use in Google Earth) or in feet (for use in certain other tools). The *curtain* button determines whether a translucent curtain will drop down from the three-dimensional flight track to the surface; this can aid in understanding the path. Go ahead and select *time-varying*, *locations*, and *Altitude* in meters with a curtain. You can leave the other controls alone

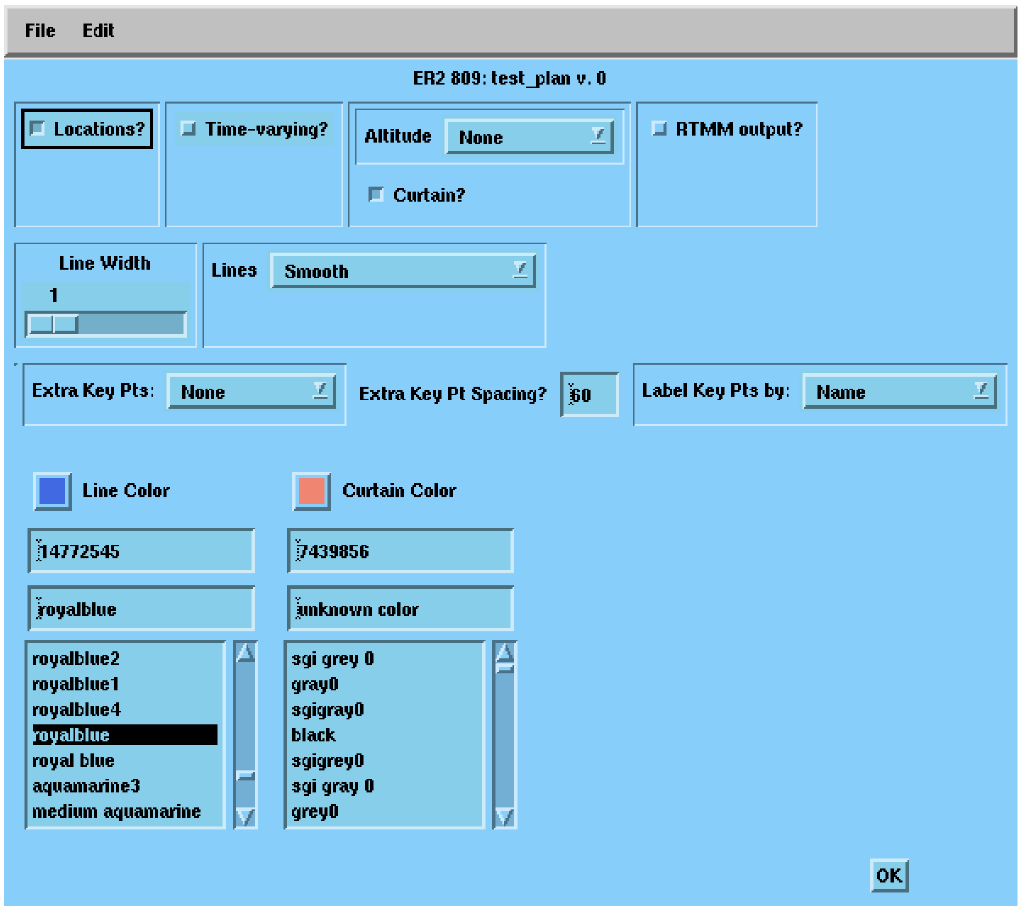

Figure 2.23: The export to KML widget

for now. Click on *OK*, and a file selection widget comes up for the output file. Click on save there, and the plan is exported to a KML file.

Load the file into Google Earth and zoom in on it. Note the curtain, and the defined locations. If you don't like the colors, you can go back to the flight planner and change them

This exercise has taken you from starting a new flight plan, to adding maneuvers, to setting up displays, and then saving your work and exporting the displays to files. There are many more sophisticated and powerful things the flight planner can help you do, but these are the basics.

Chapter 3

Meteorological Data

3.1 Local data access

The most useful feature of the flight planner is its ability to plot meteorological data with a tentative flight track overlaid. But plotting the data is possible only if the data are accessible from your computer. Typically, those data are read in in as three-dimensional arrays which are then interpolated in time and space to the either quasi-horizontal surfaces such as pressure or theta surfaces, or vertical surfaces such as curtains or straight transections. As a result, even though some kinds of data may be accessible over the Internet, efficiency considerations mean that typically the bulk of the data used by the flight planner has been in local data files.

In fact, historically the flight planner was built on top of a pre-existing data system that has been in use by our group at GSFC since the early 1990s. A locally-developed data format, called "df" is used in that data system. Although our group is migrating slowly away from "df" to other formats such as netcdf, many of the underlying routines still assume the local format.

If you are running the flight planner from a machine in the Code 614 Unix Cluster, then the data files are all available to you already, with no effort on your part. But if you are outside the cluster, then you may want to set up your own local repository of data. In these days of small portable terabyte-sized disk drives, you may find it well worth doing.

First, you want to set up a data directory in which the data will reside. This may be an external USB or Firewire drive, but it can be internal disk space on your laptop. You choose, but remember that these data can consume a lot of disk space, especially for a long mission. Purging old files to free up disk pace is your responsibility!

3.1.1 On a Mac

Once you have decided on your data directory, put the name of that directory in a file called "`Data_Root`" in your "`flightplan`" directory (i.e., the same directory as the "`flight_planner.sh`" and "`upgrade.sh`" scripts reside.) For example, if you want your data directory to be "`/Volumes/SciData/Missions`", the the file "`Data_Root`" must be a plain text file that contains the single line:

```
/Volumes/SciData/Missions
```

Next, you need to create the subdirectories and fill them with data. Look in the "`Data_Acquisition`" subdirectory of your "`flightplan`" directory. Find the "`data.table`" file and look it over to see what kinds of meteorological data might be useful in your flight planning. Each (non-comment) line in the data.table file gives the name of a data set, followed by short specification of how to obtain the data and where to put it. We have two main means of getting data: using "wget" and using "rsync". Wget is a useful program you can download from the Free Software Foundation. It can be used to download data from our web site easily, but wget does not come already installed on a Mac. On the other hand, rsync does come installed on a Mac. But to use rsync with our data.table recipes, you will need SSH login keys for the user "msnxfer" on our system. The two key files that you need are not included in this package, for security reasons. But if you email Leslie.R.Laitnasa.gov asking for these, you will be given two files to put into this directory.

To get the data from our group NASA's Goddard Space Flight Center, simply run the "`grab_data`" program. The usual syntax is: " `grab_data dataname` " where "`dataname`" is one of the entries in the file "`data.table`".

For example, to obtain the NCEP analyses and forecasts that cover the region for the SEAC4RS mission, use: " `grab_data NCEP_SEAC4RS` ". When the program is finished, the latest data will be under your data directory, for example in " `/Volumes/SciData/Missions/science/nmc/met_fields/data/GX1X1/Y2012/M05/`".

The "`grab_data`" program can take several command-line options. " `grab_data -v NCEP_SEAC4RS` " Will be a little more verbose about what it is doing.

" `grab_data -t mydata.table MYDATANAME` " will consult your own custom file, "`mydata.table`", to find out how to get the data set you call "MYDATANAME".

" `grab_data -d 2011-04-12` " will get the data for a time other than today. "`grab_data`" gets any data for the current month that it does not already have. If the date is within a few days of the beginning of the month, then data from the preceding month are also obtained. Similarly, when the date is near the end of the month, any data from the next month (e.g. forecasts) are obtained.

If you like, you can set up a cron job on your computer that will run "`grab_data`" periodically for each data set that you want to pull over.

3.1.2 Linux systems

Read the instructions above for the Mac. If you are using the "`flight_planner.sh`" script, then that procedure will probably work. Otherwise, examine that script to see what changes you need to make to get it to work in your environment.

The procedure for grabbing data files from GSFC should be nearly identical for Linux machines

3.2 Using local "df" files in the flight planner

Once you have the data flowing into your data directory, you will want to view it from within the flight planner.

In a Map Display, select *DF Met Data* under the *Data* menu on the top toolbar. A widget selection will come up, as shown in Figure 3.1, to let you pick what kind of data you want.

The top part of the widget lets you select things like the quantity, scaling and offset factors, as well as the surface onto which the data are to be interpolated. There is also a section to set how the data are to be plotted. Then, near the bottom, are controls to select which specific "df" data files are to be used.

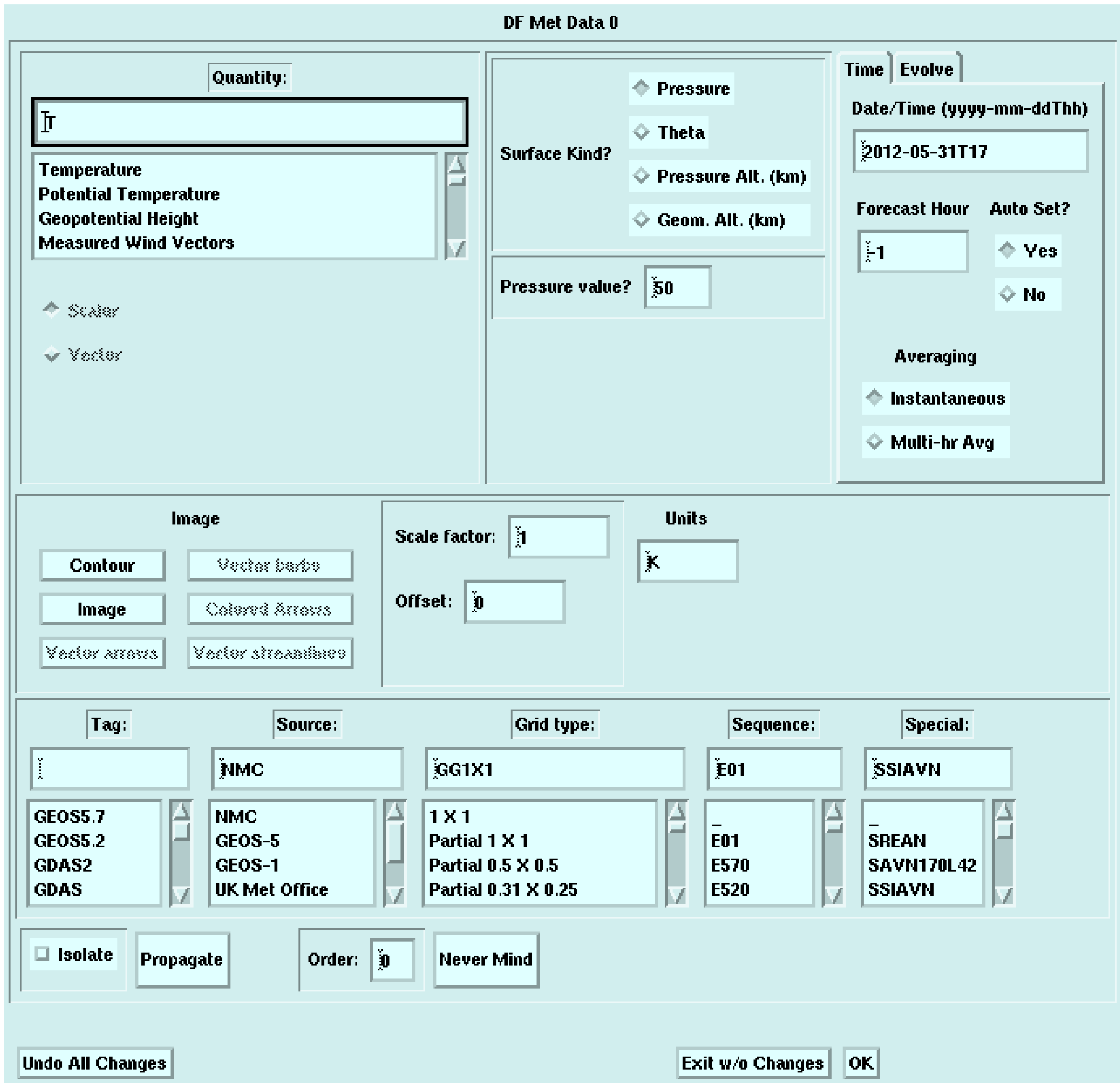

Figure 3.1: The DF Met Data Specs widget

Unfortunately, there is no menu that lets you see what data files are actually available. (This is because some quantities such as potential temperature are calculated on-the-fly from other quantities such as temperature and pressure.) So to see what data are available, you need to look in your data directory tree and decipher the file names. This is not very hard. Two typical file names are "`OMGAI12051606_GX1X1_FH42_X_E01_SAVN170L42.NMC`" and "`Z___I12051318_GX1X1_X_E01_SSIAVN.NMC`"

Let's break the first one into components:

OMGA	a four-character code that indicates the physical quantity [1] "OMGA", as you might guess, is the omega field (vertical velocity in pressure coordinates).
I	a single-character that indicates where the data are a time average ("H") or an instantaneous snapshot ("I").
12051606	This is an eight-digit code that gives the valid-at date, in yymmddhh format. Here, "12051606" means "06 UTC on May 16, 2012"
GX1X1	the horizontal grid. In this case, it covers only part of the globe ("GX"), and it has a resolution of 1 degree longitude by one degree latitude ("1X1").
FH42	specifies the forecast lead time—in this case, 42 hours. To get the model initialization time, subtract the forecast lead time from the valid-at date+time(1200 UTC on May 15, 2012, in this case)
X	file format. All the files that you see will be "X".
E01	a "sequence" code; it is a fairly arbitrary tag.
SAVN170L42	a "special" code; it, too, is a fairly arbitrary tag.
NMC	the source of the data. ("NMC" is an old name for "NCEP")

Likewise, the second file name may be decoded as:

Z___	geopotential height
I	instantaneous snapshot
12051318	valid at 2012-05-13T18 UTC
GX1X1	partial 1 by 1 horizontal grid
X	standard "df" data format
E01	sequence "E01"
SSIAVN	special "SSIAVN"
NMC	data from NCEP

Note that this file name is missing the "FH" part. This means that it hold an analysis, not a forecast. In other words, consider it the equivalent of "FH0". note that for NCEP data, the "special" code is different for forecasts and analyses.

Now go back to the DF Met Data widget controls. The basic properties at the top that you may control are:

Quantity	You can type in the four-character code in the blank, or you can click on an English descriptive string in the menu.
Surface kind	For map displays, you can choose to interpolate the data to an arbitrary quasi-horizontal surface.
surface value	(just underneath the *Surface Kind* buttons). This lets you choose the value of the surface (in mb for pressure, K for potential temperature, km for height).
Auto Set?	Click *No* to select the exact valid-at time for which you want to see the data field. *Yes* will let the flight planner pick a time for you– usually the middle of the flight (i.e., takeoff time + half the duration)
Date/Time (yyyy-mm-ddThh)	Here is where you specify the exact valid-at time that you want to see, *if* you clicked on *No* for *Auto Set?*. Since *Auto Set?* is usually *Yes*, this control is usually ignored.
Forecast Hour	This is the forecast lead time, in hours. "0" means analyses. "-1" means "pick out the smallest forecast hour that matches the other specifications".
Averaging	Choose *Instantaneous* if the fifth character of the file name is *I*, *Multi-hr Avg* if it is *H*.

You can click on the *Evolve* tab to set how time interpolation is done. By default, the flight planner interpolates the data to the *Date/Time* setting. (Hey, it's only model data!). The controls in this tab are:

Data Inc	Tells how far apart the data files are in time. Typically this is six hours (“PT6H” in ISO8601 format).
Base Hour	Tell the hour at which a day’s data files begin. Typically this is 00 UTC.
Time Interp?	*No* turns off time interpolation. In this case, you need to make sure that you specify a *Date/Time* for which you have a valid data file. and turn off *Auto Set?* as well.
Time Extend?	When you do animation for a flight that extends out beyond the time range for which you have data, the later plots will be mostly blank, with a “no data” label printed. This can be less than helpful. Click *Yes* on *Time Extend* to keep showing the last valid data for those frames.

Other controls include:

Image	The (scalar) data will be plotted as a false-color image. Clicking this button brings up a widget to let you choose data limits and a color scale.
Contour	The (scalar) data will be plotted as a contours image. Clicking this button brings up a widget to let you choose data limits, intervals, number of contours, and line thickness/color/style.
Vector Arrows	The (vector) data will be plotted as arrows. Clicking this button brings up a widget to let you choose data limits, a thinning factor (to make the plot less busy), and arrow size/color/thickness.
Vector barbs,	The (vector) data will be plotted as wind barbs. Clicking this button brings up a widget to let you choose data limits, a thinning factor, and barb size/color/thickness.
Colored Arrows	The (vector) data will be plotted as colored arrowheads. Clicking this button brings up a widget to let you choose data limits, a thinning factor, arrowhead size, and color scale.
Vector streamlines	The (vector) data will be plotted as streamlines. (Warning: vector streamlines are very slow to compute.) Clicking one of these buttons will bring up a separate control widget that lets you choose color thicknesses, data limits, and so on.
Scale factor	If you do not care for the units of the data from the files, you can multiply them by a scale factor here.
Offset	If you do not care for the units of the data from the files, you can add an offset to them here. Note that the offset is applied after the scale factor. Thus, to display temperature in degrees Fahrenheit when it is read as Kelvin, you set the offset and scale factor.
Units	This is a string to use as the new units in plot labels.

The data selection controls are:

Tag	This lets you set the *Source*, *Grid type*, *Sequence Special*, and *Averaging* controls in one step. Choose *GEOS5.7* for GMAO GEOS5 data, or *GDAS* for NCEP data. (This also lets you use forecasts or analyses, whichever exists, despite differing *Special* settings.)
Source	The data source. You can type into the entry blank at the top or click on a menu entry. Note that not all possibilities are actually listed in the menus.
Grid type	this sets the grid type
Sequence	this sets the "sequence" code.
Special	this sets the "special" code.

The remaining controls do not select data:

Propagate	If you have several data fields displayed on a map, you sometime want to change the *Source*, *Grid*, etc., settings for all of them. The button pushes the current selection settings to the other variables in this display. (But it does not affect the quantity chosen or how the quantities is plotted.)
Isolate	Sometimes when you push the *Propagate* button, you want an except for one variable. Click *Isolate* on that variable to isolate it from the effects of pushing *Propagate* on some other variable's controls.
Order	Every data plot and plot decoration is drawn in the order given by this index. By default, images have low numbers and are drawn first; contours have higher order numbers and are drawn later. Use this control to set the exact order in which the data are plotted. Be be careful: you can easily tell the flight planner to draw contours and then hide them under an image.
Never Mind	If you click this, the variable will be removed and not plotted.
Undo All Changes	Reset all controls to their original settings.
Exit w/o Changes	Reset and quit.
OK	Exit the controls, and make the plot.

In a curtain or transection plot, the controls for setting the horizontal surface are missing, but the other controls work the same.

3.3 Using local GOES images in the flight planner

The other type of local data files you can view within the flight planner are certain subsets of GOES imagery. These originate from `http://goes.gsfc.nasa.gov`. Our group reformats the images, converting them into physical units (rather than pixel values) and mapping them onto a regular longitude-latitude grid. They are then written into netcdf format. You can obtain these files in the same way as the "df" format meteorological data.

To view them, go to the *Data* menu of the Map Display widget and select *Weather Satellite Imagery*. A new Weather Satellite Imagery control panel appears, as in Figure 3.2

The controls along the top let you choose the *Satellite*, instrument *Channel*, the quantity the instrument measures from that channel (*Channel type?*), and the *Source* of the data. The controls in the *Time* and *Evolve* tabs work the same as for the DF Met Data widget described above, except that the *Evolve* tab replaces df's *Data Inc* and *Base Hour* controls with *Data times (min)* and *Time window (min)*. The former should contain a comma-separated list of minutes after the hour for which imagery regularly appears. For example, if images from a certain satellite are valid for 9:17, 9:47, 10:17, 10:47, 11:17, 11:47, and so on, then *Data times (min)* should read "17, 47". Of course, satellite imagery does not always arrive strictly on schedule, so the *Time window (min)* lets you set a window of tolerance around the times from *Data times (min)*. If the window is set to "3", then images from 10:18 or 10:16 will be accepted in the place of a missing image from time 10:17.

Underneath the top row is an important menu, *Region*. This selects which geographical subset of the data we want to view.

Note that our group does not reformat all regions from the GOES web site, nor all channels of the regions we do get. Send us requests if you need something that we are not providing.

For brightness temperature data, a color scale is used that highlights colder temperatures (i.e., higher cloud tops). Thus there are three points in the temperature limits: the warmest T to display, the T at which highlighting begins, and the highest T to display/ You can also plot in units of Kelvin or Celsius. The data limits for albedo are set in separate max and min controls.

The remaining controls work the same as for the DF Met Data widget

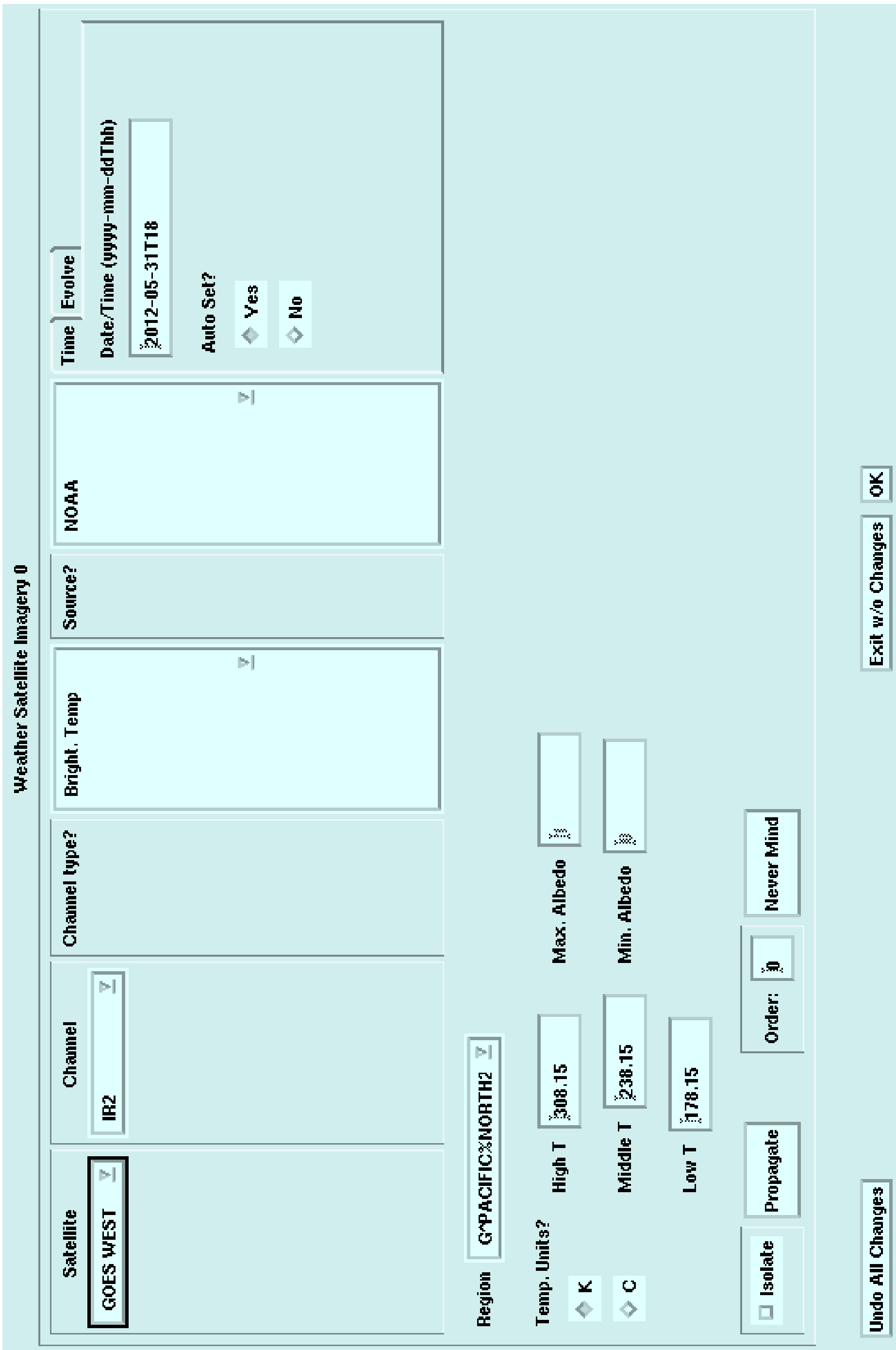

Figure 3.2: The Weather Satellite Data Specs widget

described above.

3.4 Using GMAO internet data in the flight planner

If you want to look at meteorological data from the Goddard Modeling and Assimilation Office (GMAO), then you can do by using a data source in the flight planner that reads their data from their OPeNDAP data portal over the Internet. This frees you from having to bring data files over locally, but it is a little slower.

In aMap Display's *Data* menu, click on *GMAO Portal Data*. The GMAO Portal Data widget will appear, as shown in Figure 3.3.

The prominent feature in the widget is the hierarchical tree of quantities, which reflects the organizational tree of the "fp" data stream in GMAO's portal. If you are familiar with that organization, then you should be able to find the data quantity that you want. Otherwise, you can use the *Search (regex)* control at the top: type in a regular expression (a simple "temperature" will suffice for temperature and press ENTER. The first match between your search string and the tree of quantities will show up, highlighted. You can move to the next match by clicking on the *Next* button, or move backwards by clicking on the *Previous* button.

Underneath these, the *Strict* and *Flexible* determine how strict the match is. With the *Flexible* setting, if a quantity is not found in one file, it may be read from another. Usually, this lets you read forecast data for times where there is no assimilation data yet.

The GMAO data "fp" data fields have a horizontal resolution of 0.25 degree in latitude and 0.3125 degree in longitude. Thus, you really do not want to read in the whole global extent at full resolution if you can help it. If a map display is zoomed in tightly, only the part of the field that is visible is requested from the GMAO portal, and that is usually only a small portion of the globe. conversely, if the map is zoomed out to a full global view, you would never be able to see the full fine resolution of the data. By default, the flight planner will request only every Nth data point in those cases, thinning out the data. In other words, smaller geographical areas get higher resolution, and larger geographical areas get lower resolution. You can control this thinning by the *Horizontal Thinning Factor* slider.

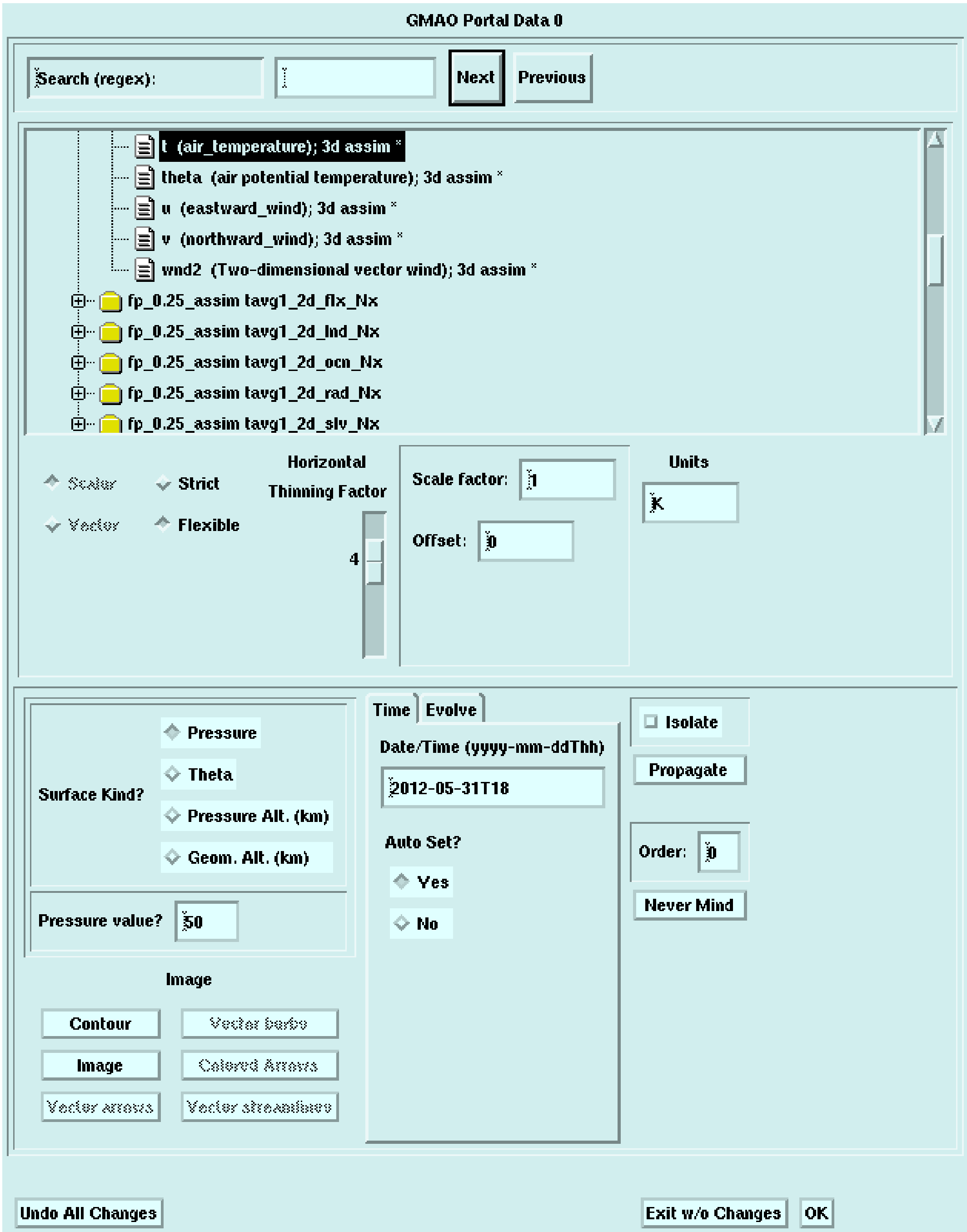

Figure 3.3: The GMAO Portal Data Specs widget

The rest of the controls work the same as for the DF Met Data widget described above.

3.5 Using user-supplied data in the flight planner

Having only only three actual data sources can seem somewhat limiting, especially if you have some kind of specialized model output you would like to view from withn the flight planner. The flight planner provides a way to bring such data in and view it along with the rest. The benefit of user-supplied data is that you can display any kind of data that you want. The drawback if that you have to supply the reader routine yourself.

From the *Data* menu on the Map display, select *User-supplied Map Data*. A new widget will appear as in Figure 3.4.

Enter the quantity that you want to view, and check whether that quantity is a scalar or a vector field. You can set the scale factor, offset, and units as in the other specification widgets.

Under *Reader Function*, you must enter the name of an IDL function that reads the data. You or your colleagues will supply this routine. This function must have a particular form for its calling sequence. (See below for the details.)

The routine name is followed by four "tag" fields. What these fields mean and how they are interpreted depends only on the user-supplied routine. Some might interpret *Tag1* as a pressure surface value, while others might interpret it as a satellite channel number. (Similarly, the name that you typed in for *Quantity* is meaningful only to the user-supplied routine; the name the routine uses for temperature might be "T" or "temp" or even "spizzywig". The flight planner will print this name as a label without worrying about its meaning.)

As with the other data sources, you can specify a valid-at time for the data that you want to see in the *Date/Time* field, or rely on the flightplanner to ask for a time automatically by checking the *Yes* on *Auto Set?*. And as with the other data sources, you can turn time interpolation and extension of data beyond its valid-at time either on or off.

Depending on whether the quantity is a scalar or a vector, you can choose how it is to be plotted using the *Contour*, *Image*, *Vector Arrows*, *Vector Barbs*,

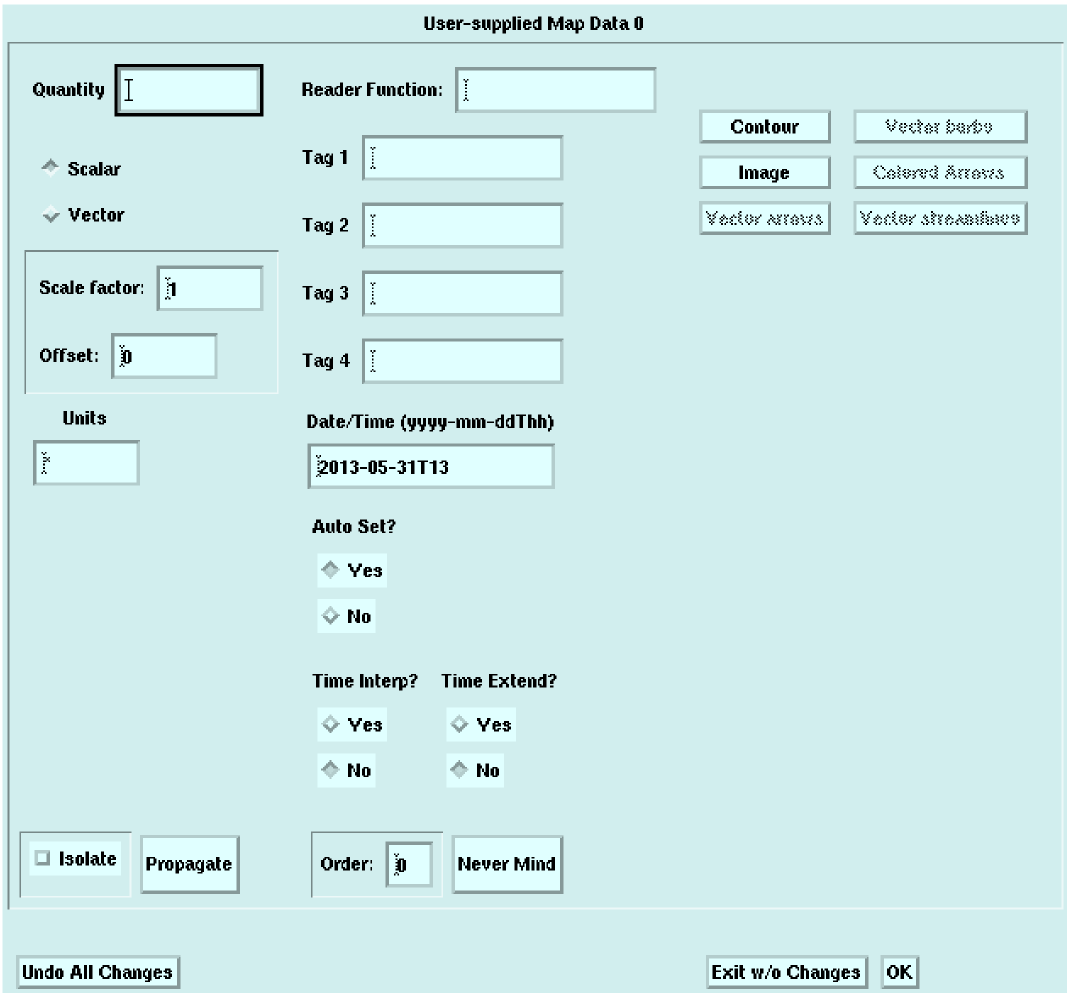

Figure 3.4: The User-Specified Data Specs widget

Colored Arrows, or *Vector streamlines* buttons.

The remaining controls work the same as with other data sources.

3.5.1 The user-supplied reader function

The user-supplied reader routine must be an IDL function that takes six parameters and uses a certain set of keywords. The function return value is a string value. If the data requested by the user is being provided by the routine, this string should be empty (“”); if there was any kind of error, then this string shold contain a brief message describing the error.

The six required parameters are:

QUANTITY the string that the user types into the *Quanity* field in the contrl widget. It denotes the physical quantity that is desired. The string follows whatever naming convention the user-supplied routine's author wishes to follow.

DATE a UTC time stamp in the ISO8601 string format (e.g., “2013-05-31T14:56” for 14:56 on May 31, 2013). This time stamp is supplied by the user or automatically by the flight planner. If data are available only for certain specific time snapshots, then it should be noted that those times are unlikely to correspond the this requested time. It is up to the routine what action should be taken: return an error, or find the time snapshot that is nearest to the requested time.

TAG1 an arbitrary string that may be used by the routine to distinguish one data collection from another.

TAG2 an arbitrary string that may be used by the routine to distinguish one data collection from another.

TAG3 an arbitrary string that may be used by the routine to distinguish one data collection from another.

TAG4 an arbitrary string that may be used by the routine to distinguish one data collection from another. The four parameters TAG1 through TAG4 could be surface type, surface value, forecast model initialization time, and model name. Or they could be satellite instrument channel, satellite platform, special processing code, and satellite owner. Or they could all be completely ignored. How to interpret them is entirely up to the routine.

There are two input keywords that the routine should receive as well:

LONRANGE a two-element vector that limits the range of longitudes that are being requested. For high-resolution data to be displayed on a zoomed-in map, this can be useful in limiting the amount of data that needs to be read and held in memory. The first element of the vector is the westernmost longitude, and the second element is the easternmost longitude. Note that the range [-50, 50] would straddle the Atlantic ocean, while the range [50, -50] straddles the International Date Line.

LATRANGE a two-element vector that limits the range of latitudes that are being requested. The first element is the southernmost latitude of the range, and the second element is the northernmost latitude. It is up to the routine how strictly to interpret the LONRANGE and LATRANGE keywords; a grid point or two may extend beyond the boundaries, or the boundaries may even be ignored. But they must be accepted as part of the calling sequence.

Here are the keywords that the user-supplied routine must return to the calling routine:

DATA the array of quasi-horizontal data, as a two-dimensional (longitude x latitude) grid of floating-point numbers.

DAT2 If the quantity requested is a vector field, then this is the second component of the vector. For example, if horizontal wind is requested, then DATA would contain the zonal component and DAT2 would contain the meridional component. If the field is a scalar then nothing is returned in this keyword.

LONS the longitude gridpoints of the data

LATS the latitude gridpoints of the data

TIMESTAMP = (string) the valid-at time stamp of the returned data (ISO8601 format) Note that this might or might not match the time requested by the calling routine in the DATE parameter.

SFC_TYPE a number that indicates the kind of quasi-horizontal surface on which the data exist. This is needed because the flight planner can plot data from any number of kinds of surfaces. Acceptable values are:

- **0** pressure
- **1** potential temperature
- **2** pressure altitude
- **3** geometric altitude
- **4** model level
- **5** intrinsically 2D quantity (e.g., tropopause, earth's surface)

SFC_VALUE = a floating-point number giving the value of the quasi-horizontal surface (e.g, 100.0 if the data are on the 100 mb pressure surface)

VECTOR = 0 if the returned data is a scalar quantity, 1 if a vector

SNAME = (string) a short name for the quantity returned

LNAME = (string) a longer, more user-readable name fo the quantity returned

UNITS = (string) the units of the data returned

LABEL = (string) a label that can further describe the data

BADVALUE = a floating-point data value to be used as the bad-or-missing-data flag

FCST = 0 for actual data, or an integer indictating a forecast lead time, in hours

So your function calling sequence might look something like this:

```
err = YOUR_FUNCTION_HERE( quant, date, tag1, tag2, tag3, tag4 $
      , lonrange=lonrange, latrange=latrange $
      , data=data ,dat2=data2, lons=lons, lats=lats, timestamp=timestamp $
      , sfc_type=sfc_type, sfc_value=sfcval, badvalue=bad, fcst=fcst $
      , shortname=sname, longname=lname, units=units, label=label )
```

For an example, find and examine the file flt_datamap_sza.pro.

Chapter 4

Advanced Techniques

In this chapter, you can learn about some powerful additional capabilities of the flight planner. With these, you can easily devise some rather complicated patterns. But try to use some caution in this, and don't go overboard with it. The flight planner can help you eliminate plans that are impossible to fly, but some plans that are possible are nevertheless impractical. Remember that at some point a pilot will be asked to fly your plan. Put yourself in his shoes for a moment before before sending him down a twisty crooked path.

4.1 Automatically-Generated Defined Locations

You can define locations by typing the latitude and longitude coordinates into the defined locations table, and you can define them by clicking on a Map Display. But sometimes you will want to calculate a series of defined locations with reference to some other defined point. For example, to remotely sense a storm system far beneath the aircraft, you may want to fly back and forth between points that are spaced around a circle that is centered on the storm. You could draw a range ring decoration on a map, and click to create new defined locations around that ring, eye-balling their coordinates. But it you want a higher degree of precision, you can have the flight planner automatically generate new locations for you.

Just above the defined-locations table in the Flight Plan control panel, between the *Add* and *Delete* buttons, you will find the *Auto-Gen* button. This brings up a menu of auto-generations choices.

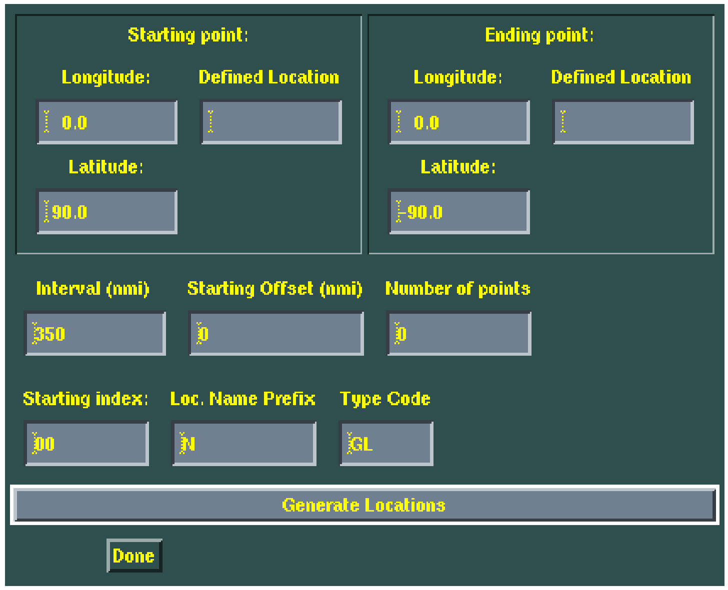

Figure 4.1: The Gen.-Along-Line widget

4.1.1 Along a line

Gen. along line lets you space points evenly along a straight-line segment. A Gen. Along Line widget appears as in Figure 4.1 to let you specify how the points are defined. In the upper-left are the *Starting point* controls. You can type in a *latitude* and *longitude*, or you can type in the name of an already-existing *defined location*. (If you do the latter, press ENTER after typing the name, so that its coordinates can be looked up and printed into the *latitude* and *longitude* blanks.) You specify the*Ending point* of the straight-line segment the same way.

Use *Interval (nmi)* to specify the distance between points (in nautical miles only), *Starting Offset (nmi)* lets you set an offset from the starting point at which the first point generated will be defined. The *Number of points* specifies the number of points you want; if 0, then as many as will fit along the line are generated.

Those controls specify where to generate the new locations, but how should they be named? Each one will begin with the string in *Loc. Name Prefix*, followed by an integer number. The number of the first point generated will be given by *Starting Index:*. Note that the number of digits that you specify here will be the minimum number of digits used throughout. So ”01” will yield "01", 02", 03", etc., while "001" will yield "001", "002", 003", and so on.

Type Code lets you set a code for the *Type* column in the defined-locations list. This can be useful in classifying different locations into different groups. And that, in turn, can be useful in extracting those groups for printing in the Waypoints Listing Display.

Once you have your specification set up, click on *Generate Locations*, and the generated locations will appear in the defined-locations list. Note that the new locations will not be added to the flight plan itself. After all, the flight planner has no way of knowing for sure what you want to do with them. But if the locations to lie along the flight track, you will see them that way in the various displays.

If you click on *Generate Locations* again, the points will be re-generated. Any locations already defined in the defined-locations table will be replaced by the new generated locations.

4.1.2 Along a circle

Gen. around circle lets you space points evenly around a circle. A Gen. Along Circle widget appears as in Figure 4.2 to let you specify how the points are defined. In the upper-left are the *Center point* controls. You can type in a *latitude* and *longitude*, or you can type in the name of an already-existing *defined location*. (If you do the latter, press ENTER after typing the name, so that its coordinates can be looked up and printed into the *latitude* and *longitude* blanks.)

The *Radius (nmi)* and *Number of points* controls, specify how many points to place around how big a circle. *Starting Angle (deg. from North)* specifies where to put the first point.

The other controls work the same as in the Gen. Along Line widget described above.

4.1.3 From a file

The flight planner cannot automatically generate every possible set of defined locations you might need, but it does let you use a separate program to generate your desired coordinates and writ them to a file. The you can use the *Gen. from file* widget (as shown in Figure 4.3) in the flight planner to read these points in and turn them into defined locations.

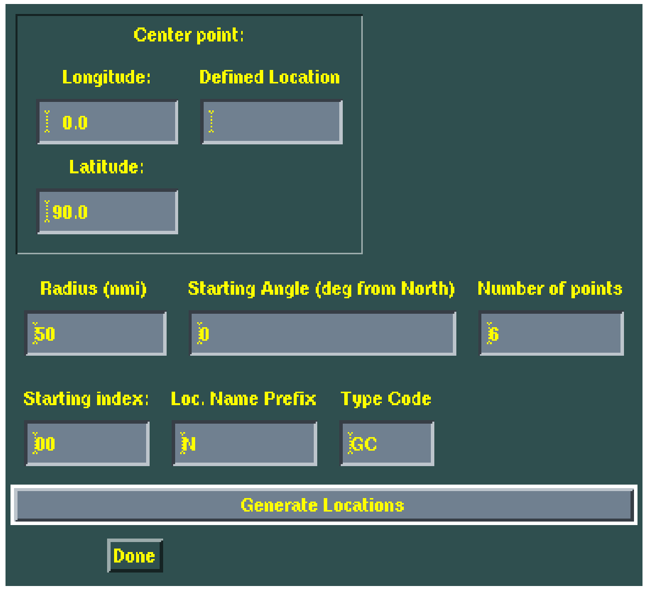

Figure 4.2: The Gen.-Around-Circle widget

At the left top of the widget is a file selection control; choose the file that contains the points. To the right is a menu button that lets you choose the format; currently only ".txt" is allowed.

The format of the ".txt" file is this: each line of this plain text file consists of one latitude, followed by one longitude, optionally followed by a label (leading alphabetic character, followed by alphanumeric characters and/or underscores), with at least one space character separating them. The longitudes and latitudes may be in any of the forms in which you could enter them into the flight planner by hand. If the label is present, then it is used as the location name; otherwise, the name is automatically generated as with the other auto-generated locations. Any lines that fail to follow this format are ignored.

The *Relocate* control, if set to *Yes*, will change the location of the first point read in to the point set by the *Relocation Start:* controls. You can type in a *latitude* and *longitude* here, or you can type in the name of an already-existing *defined location*. (If you do the latter, press ENTER after typing the name, so that its coordinates can be looked up and printed into the *latitude* and *longitude* blanks.) Once the first point has been re-located this way, all subsequent points read in are relocated relative to the first point.

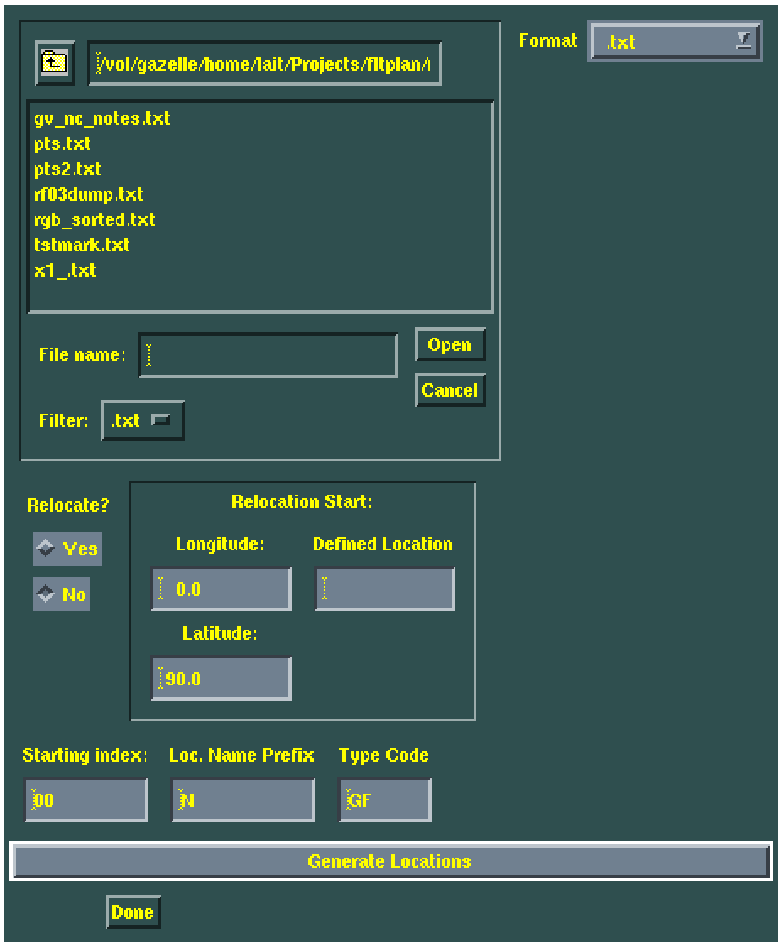

Figure 4.3: The Gen.-From-File widget

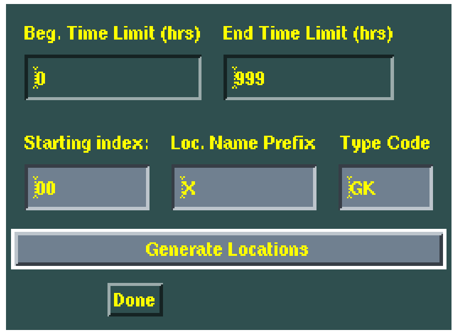

Figure 4.4: The Gen.-From-Key-Points widget

The other controls work the same as in the Gen. Along Line widget described above.

4.1.4 From key points

Gen. from key points finds key points along the flight track, where the direction or altitude changes suddenly, and where those points do not already occur at a defined location, new defined locations are created to mark them. Its control panel looks like Figure 4.4.

Typically, there is no purpose in assigning names to points very near takeoff and landing, so the *Beg. Time Limit (hrs)* and *End Time Limit (hrs)* let you limit the time span over which the key points will be found and turned into defined locations.

The other controls work the same as in the Gen. Along Line widget described above.

4.2 Variables and Expressions

Sometimes, you will want to refer repeatedly to the sane distance or angle, over and over again in different maneuvers. You could simply enter the number into a parameter as you create each maneuver. But if you should change your mind about the value (say, changing 100 km to 120 km), then you would need to edit each maneuver, in turn, to replace that value.

There is a better way. You can define variables whose names can then be entered into any maneuver parameters. the way to define a variable is by setting its value with a pseudo-maneuver. Add a new maneuver to the flight plan, and then near the bottom of the Choose Flight Maneuver widget you will see the *defs* group. Open that and select one of those choices. *Define a variable* is intended for unitless quantities such as angles. *Define a position* is for variable that you can use in the place of a defined location. The others define numerical constants whose units depend on the current settings above the maneuver list in the Flight Plan widget.

If you select *Define a horiz. distance variable*, the define_hdist editing panel that appears has two required arguments: VARIABLE and HDIST. In the VARIABLE blank, enter the name of the variable that you want to define. All variable names must start with a dollar sign ("$"), so that the flight planner can distinguish them from location names. The next character must be alphabetic, and subsequent characters may be alphabetic, numeric, or underscore ("_"). You can use uppercase and lowercase letters; "$ABC" is a different variable from "$abc".

For the HDIST value, enter a number in the units that you are using (km, nmi, or degrees latitude).

Click on *OK*, and the new pseudo-maneuver will appear in the maneuver list. It will appear green, because it is not a real maneuver that actually affects the state of an aircraft. Note that a variable is not defined until its definition maneuver is encountered during the simulation after you click on *Go*. Variables can be redefined as often as you wish. When a variable is referenced in a parameter of a regular maneuver, the value used is the latest value that was set at that point in the simulation. You can redefine a variable as a different type; "$A" may be defined by define_hdist as a distance in one place, by define_var as a unitless number in another place, and by define_pos as a location in another. It is up to you to avoid confusing yourself.

To use the variable as a parameter in a regular maneuver, simply enter its name (including the leading "$") into the entry blank for that parameter. If the variable is not yet defined at that point in the plan, the flight planner will flag that as an error for you, and halt the simulation.

You can even use a variable as the value in another variable definition. In fact, you can do something even more powerful: you can use an arbitrary arithmetic expression in the value field. Expressions are strings that begin with an equals sign ("="). After the equals sign, you can enter any arithmetic expression involving numbers and/or variables.

Valid examples are "`"= 3 + 45.0/3`"" (which yields the value 18.0), and "`"= (4+5)*2 - $A*$B/5.0 + 1`"" (which depends on the values of variables

Tip:

You can use expressions not only in valuable definitions, but also directly as parameter values in regular maneuvers.

"$A" and "$B".

The complete list of operators is:

operator	*operation*	*example(s)*
+	addition	4 + 5 (yields 9)
-	subtraction	7 - 3 (yields 4)
*	multiplication	2 * 3 (yields 6)
/	division	7 / 2 (yields 3.5)
%	modulus/remainder	8 % 3 (yields 2)
^	power	3 ^ 2 (yields 9)
!	logical not	! 0 (yields 1), ! 3 yields 0
==	equals	2 == 1 (yields 0), 5 == 5 (yields 1)
!=	not equals	2 != 1 (yields 1), 5 != 5 (yields 0)
<	less than	3 < 2 (yields 0)
>	greater than	3 > 2 (yields 1)
<=	less than or equal to	3 >= 3 (yields 1)
>=	greater than or equal to	3 <= 7 (yields 1)

Some functions are defined as well, so that you can calculate things such as ""=5.5*COS($ANGLE)"". The available functions are:

name	*function*	*example*	*arguments*
COS	cosine	COS($angle)	$angle = an angle, in degrees clockwise from East.
SIN	sine	SIN($angle)	$angle = an angle, in degrees clockwise from East.
TAN	tangent	TAN($angle)	$angle = an angle, in degrees clockwise from East.
ARCCOS	arccosine (returned as degrees clockwise from East)	ARCCOS($C)	$C = the number to take the arccosine of
ARCSIN	arcsine (returned as degrees clockwise from East)	ARCSIN($S)	$S = the number to take the arcsine of
ARCTAN	arctangent (returned as degrees clockwise from East)	ARCTAN($T)	$T = the number to take the arctangent of
SQRT	square root	SQRT($S)	$S = the number to take the square root of
ABS	absolute value	ABS($A)	$A = the number to take the absolute of
TRUNCATE	returns the integer part of	TRUNCATE($F)	$F = the number whose integer part is to be returned
ROUND	rounds a number to the nearest integer	ROUND($F)	$F the number to be rounded

name	*function*	*example*	*arguments*
POINT	returns a location	POINT($LON, $LAT)	$LON = the longitude of the point, $LAT = the latitude of the point
LAT	returns the latitude of a location	LAT($LOC)	$LOC = a location
LON	returns the longitude of a location	LON($LOC)	$LOC = a location
DISTANCE	returns the great-circle distance between two locations	DISTANCE($LOC1, $LOC2)	$LOC1, $LOC2 = the two locations
BEARING	returns the great-circle bearing from $LOC1 to $LOC2	BEARING($LOC1, $LOC2)	$LOC1, $LOC2 = the two locations
FROM	returns a new location that is a given distance and bearing from a given location	FROM($LOC, $D, $B)	$LOC = the origin location, $D = the distance, $B = the bearing

4.3 Location Specifications

You will note that the defined-locations table in the Flight Plan control panel is made up of two tabs, titled *Main* and *Specs*. Ordinarily, you enter names, longitudes, latitudes, etc., by typing them into the proper row in the *Main* tab. But it is also possible to define a location using some kind of expression. This is typically used to define a location relative to another location. Then if the original location is moved, the second location (defined relative to the first) will move automatically as well. This lets you define entire p[atterns of waypoints that can easily be relocated.

As an example, define two points, “AA” and “’BB” as shown in Figure 4.5.

Now click on the *Specs* tab with switch to that view of the table. Click on the "Specs" column of the "BB" row, type "?AA" and press ENTER.

The result, seen in Figure 4.6, shows that location "BB" is now defined in terms of location "AA" using an expression. Specifically, "BB' lines along a great-circle line 671.959 km away from "AA" at a bearing of -47.5312 degrees.

Now click on the *Main* tab. Change the latitude of 'AA" to 25.0 and press ENTER. You will find that the location of "BB" automatically changes as well.

The "?AA" entry is merely a shortcut. You may manually enter any expression into the *Specs* table that will result in a location. This means that you must use the POINT or the FROM functions at some point. But their arguments may be as elaborate as you care to type in. You can also define locations in temrs of other locations, which are defined in terms of other locations, nested up to 50 deep.

To un-link a location so that it is no longer relative, you can either type a blank into its "Spec" field, or change its longitude or latitude manually (the "Spec" field will automatically be reset to blank). Thus, you can change location "BB" automatially by changing "AA', but if you change "BB" yourself, "AA" does *not* change at all. Relative definitions do not work backward.

Note that when you automatically generate defined locations long a line or around a circle as described ealier in this chapter, those newly-defined locations are relative to the line endpoints or the circle center.

(If you are using an EditMap, Display, you can also define relative locaitons by highlighting the reference location first to be used as a base, then shift-left-clicking to highlight other locations that you want to define relative to the first. Once you have them all highlighted, press the "r" key on the keyboard, and the other locations will become defined relative to the first.)

At this point, you may be wondering if you can use variables in these location specs expressions. The answer is no. Variables and position expressions are defined only while the flight plan simulation is running (i.e., for a few milliseconds after pressing the *Go* button). The entries in the defined locations table are more permanent, existing before and after the simulation. You can think of the variables and position expressions as being analogous to the variables in a running computer program: they really exist only while the program is running. The defined locations are more like a disk file of data that the program reads on startup. The contents of a disk file cannot reach into the running program and grab variable values. In the same way, the defined locations table cannot reach into the flight plan and grab variable

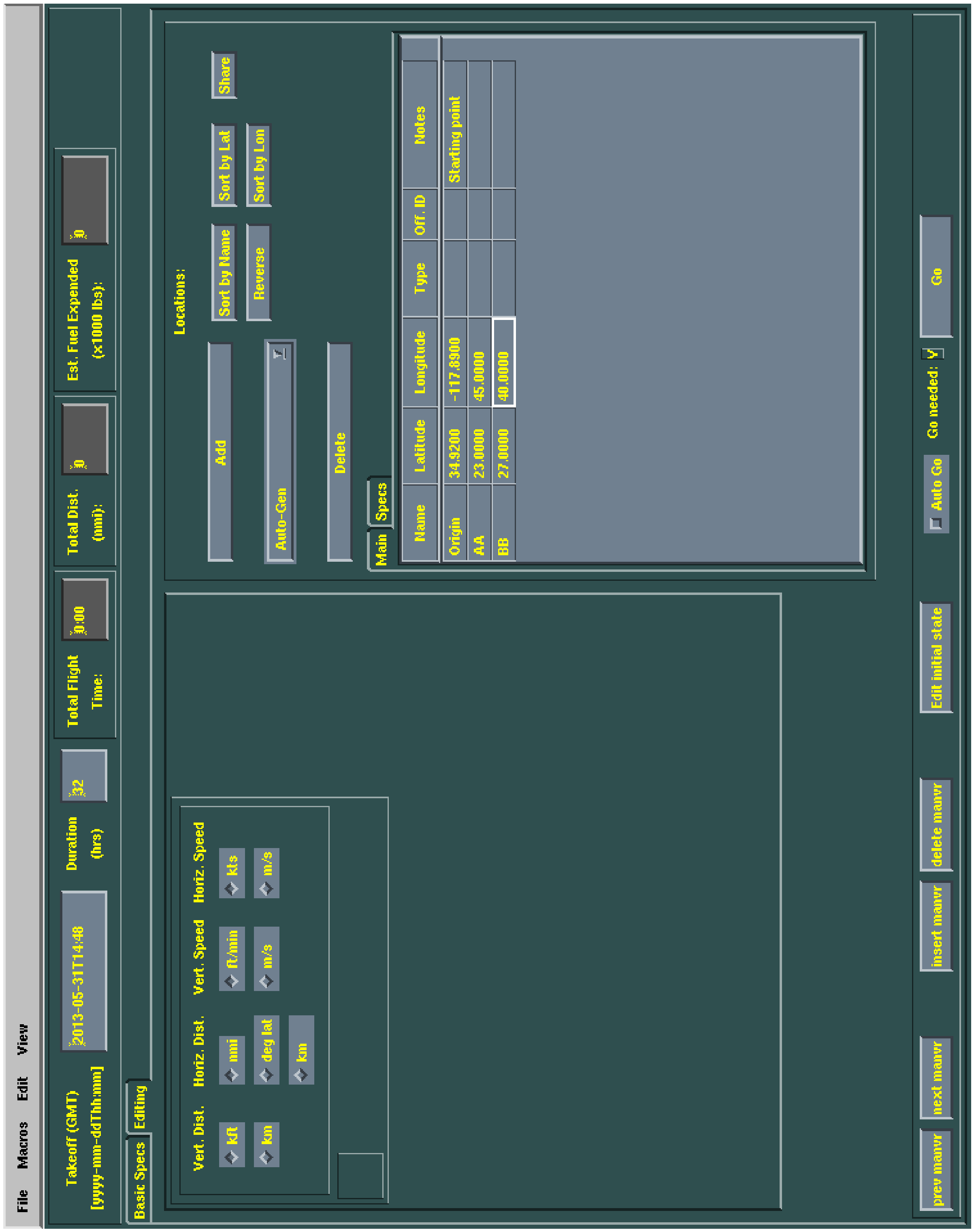

Figure 4.5: New Locations “AA” and “BB”

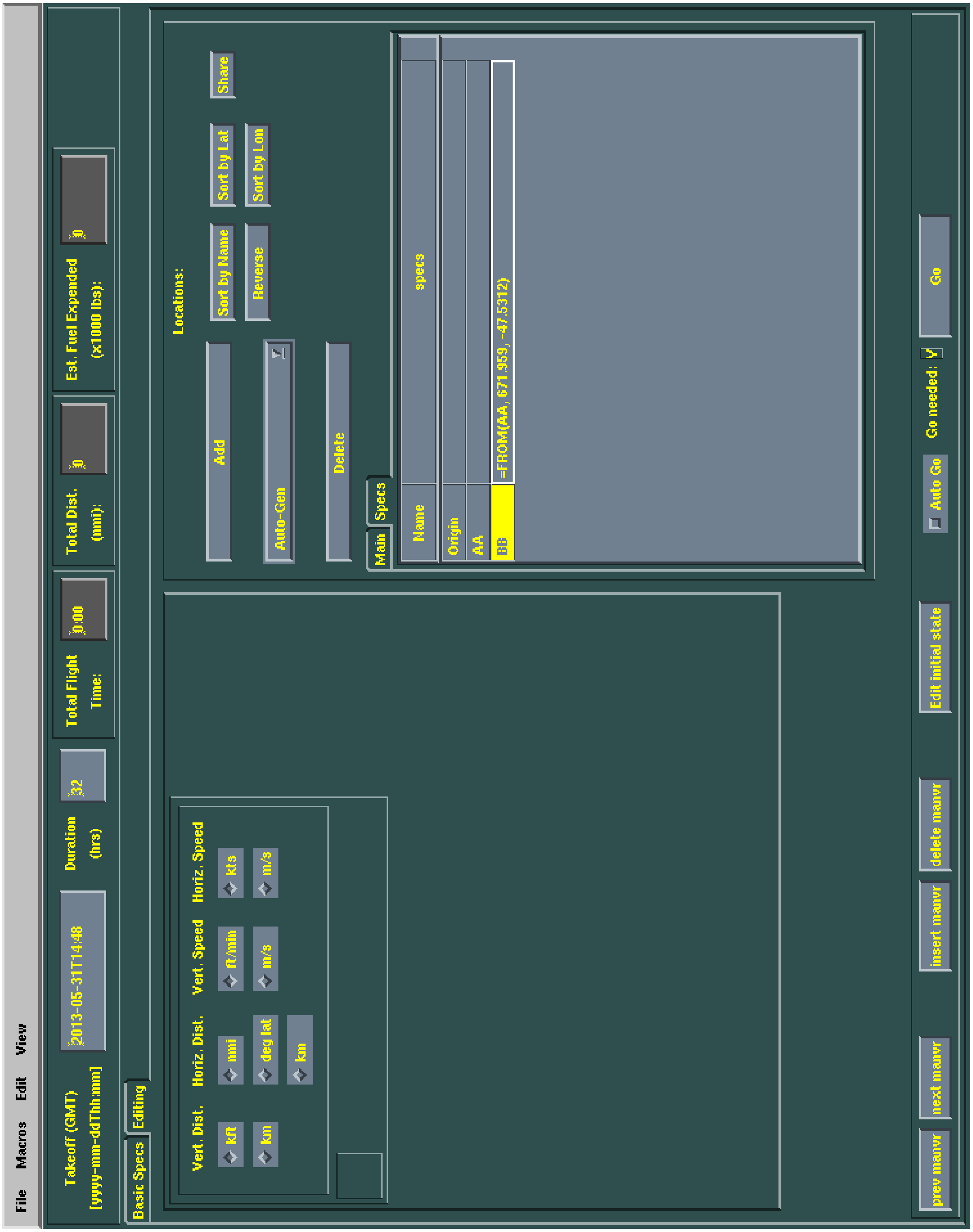

Figure 4.6: New Locations “AA” and “BB”

and position values.

However, it is possible for running programs to write values out to disk. And, analogously, it is possible for a flight plan during its simulation to write new entries into the defined locations table. This can be done with the "defined_loc" pseudo-maneuver. But be careful: if you define a location this way, and then change it manually, your change will be lost as soon as you click on "Go". This is like editing a file and then re-running the program that wrote the file in the first place; your edits will be overwritten.

4.4 Control Maneuvers

The presence of logical operators in expression is a hint that you might be able to use some kind of test-and-branch programming construct in your flight plans. And indeed you can. Like the variable definitions, program control is done via special pseudo-maneuvers that do not directly changes the state of the aircraft.

Add a new maneuver to the flight plan, and then close the bottom of the Choose Flight Maneuver widget you will see the *cntrl* group. Open that and select one of those choices:

description	*maneuver name*
Define a comment	comment
Start a while-block	while
End a while-block	endwhile
Start an if-block	if
Begin the else part of an if-block	else
End an if-block	endif
Start a repeat-block	repeat
End a repeat-block	until
Start a for-block	for
end a for-block	next
Define a label	label
Go to a label	goto

The Comment maneuver does not really control program flow, but it lets you document what a section of the flight plan is doing.

The if—endif and if—else—endif constructs let you run alternative block of maneuvers depending on the value of a test condition in the if maneuver. If the value is non-zero, the maneuvers in the "if" block are used; other wise they are skipped and the maneuvers in the "else" block are used, if present.

The while–endwhile, repeat–until, and for—next implement looping, The first two loop as long as a test conditional value is non-zero. For while–endwhile, the test is in the while maneuver at the top of the loop. For repeat–until, the test is in the until maneuver at the bottom of the loop.

The for takes four parameters: the name of a loop variable, its starting value, its ending value, and the increment value to be added to the loop variable after each iteration.

The label defines a arbitrary point in the maneuver list to which you can jump with a goto maneuver.

Just as variable definition pseudo-maneuvers show up in green on the maneuver list, these control pseudo-maneuvers show up in blue.

As an example, suppose you want to fly a lawnmower pattern of length 200 km and width 50 km. You might set up a sequence of maneuvers like this:

define_hdist	VARIABLE="`$LEN`", HDIST="200"
define_hdist	VARIABLE="`$WID`", HDIST="50"
for	VARIABLE="`$I`", START="1", END="5", INC="1"
if	TEST="`=$N % 2`"
define_var	VARIABLE="`$ANG`", VALUE="90"
else	
define_var	VARIABLE="`$ANG`", VALUE="-90"
endif	
stlevel_dist	DIST="`$LEN`"
turn_angle	ANGLE="`$ANG`"
stlevel_dist	DIST="`$WID`"
turn_angle	ANGLE="`$ANG`"
next	

4.5 Macros

Setting up interesting sampling patterns by using variables, expressions, and control pseudo-maneuvers is all well and good, but it would tiresome to set up, say, a lawnmower pattern, maneuver by maneuver, every time you wanted to put such a sequence into a flight plan. It would be useful, then, to be able to save those parts of a flight plan by themselves and then insert them into other flight plans later. And that is what "macros" are for.

Every maneuver control in the maneuver list on the Flight Plan panel has a little *M* button that you can toggle on and off. (See Figure 2.10.) Turning this on signifies that this maneuver to to be part of a macro. You can make any number of maneuvers part of the macro, but they all have to be contiguous, following one after the next in the maneuver list.

Once you have a set of maneuvers set to be in the macro, you can save the macro to a file. From the *Macros* menu in the top menu bar of the Flight Plan widget, select *Save flight macro*. A file selection widget will appear. Choose the file name to save to (it must end with ".mflt"), and click *Save*.

Later, you can insert the saved macro into a new flight plan that you are working on. Find the maneuver in your plan just after which you want to insert the macro. Make that maneuver the currently-active one by clicking on its indicator light to turn is yellow. Now go to the *Macros* menu and select *Load flight macro*. A file selection widget will appear. Select the macro you want to load, and its maneuvers will be added to you current plan. Click on Go to see how the plan now looks.

Tip:

If you need to delete a bunch of maneuvers all at once, you can check their M buttons, then delete the macro.

If you do not like what you see, you can delete the macro that you just added, since its maneuvers' *M* boxes are all still checked. Go to the *Macros* menu and click on *Delete Flight Macro*. Those maneuver will be removed form the plan. Click *Go* to see your older plan, restored.

Chapter 5

How Do I . . . ?

5.1 View Special Use Airspace?

You have a flight plan, but you are worried that the path might take the aircraft into restricted airspace. The pilot or navigator is the final word on this, of course, but you would like to know if this is even an issue before you talk with them.

There is a decoration for the Map Display, Restricted airspace, which handles this. It does require special text files whose names in with ".sua". For the United States, find the "`sua_gen.pl`" program among the flight planner program files and run it, saving its output to a file whose name ends with ".sua".

Note that the Restricted airspace control widget lets you set the color, thickness, labeling, etc., of each of several categories of special-use airspace, independently.

5.2 Re-order plots and decorations?

You have a plot in which several temperature contours, FIR boundaries, range rings, etc., are all drawn together. You are really interested in the temperatures, but the other lines are plotted on top of them and obscure the temperatures. You can go to the *Edit* menu of the display, and edit each decoration and data item, changing the *Order* value in each one. Make the temperature's *Order* larger than the others, and it will be plotted second-to-last, on top of everything else except the flight track.

5.3 Build a library of maneuvers?

You have a sequence of maneuvers that you find you keep using again and again. You would like to isolate these and save them into files, so that you can load them in whenever you want. This is exactly what macros are for.

Check the *M* macro button on each maneuver of the group that you want to save. Note that all the maneuvers that you check this way must be contiguous, with no gaps between them in the list of maneuvers. Then go to the *Macros* menu in the top menu bar of the Flight Plan widget, and select *Save flight macro*. Use the file selection widget that appears to set your output file and click *OK*.

Tip:

When building a library of macros, it is helpful to insert a label maneuver at the beginning to show where it starts, and one at the end as well.

To load a macro, make sure that the maneuver in the maneuver list that is just before the point of insertion is active (i.e., that it has its yellow indicator light lit). If not, then click on that maneuver's indicator light to make it active. Then go to the *Macros* menu in the top menu bar of the Flight Plan widget, and select *Load flight macro*. The new group of maneuvers will be loaded into the flight plan just as if you have added them individually.

5.4 View images from the web?

One of your colleagues has put up a useful data plot on a map on his or her web site. The flight planner does not have access to the data from which the plot was made, so you cannot put it up on your map display. What do you do? You load your colleague's image from the web and display it as a decoration.

Select *External Images* from the *Decorations* menu of the Map Display. In the External Images widget that appears, you will see an entry blank at the top, *Image file:*. This may be either a local file or a URL (e.g., "http://somewhere.edu/my_image.png"). But the image must be on a straight regular longitude-latitude grid.

Tip:

You may be able to cut and paste the URL from your web browser into the Image File: entry blank.

You can select the *Image Format*, but usually the file name extension will let the flight planner determine that automatically.

You can also do something special with the file name/URL: you can insert a pattern to be matched for a date or time. If the image decoration is for a plot that is valid for 2012-07-15T03:40, then the file name "my_image_%Y-%m-%d.png" will be translated to "my_image_2010-07-15.png". The codes that can follow the "%" are taken from the Unix "`date`" command:

Code	Description	2012-07-05T03:40:13 example
Y	4-digit year	2012
y	2-digit year	12
m	2-digit month number	07
K	month number	7
b	month abbreviation	Jul
E	uppercase month abbreviation	JUL
d	2-digit day	05
e	day	5
H	2-digit hour	03
I	hour	5
M	2-digit minute	40
S	2-digit second	13
j	day-of-year	187

There is one caveat, though: once the date and time of the plot has been substituted into the file name or URL pattern, it must match an actual file name or URL exactly. The flight planner does *not* search for the file or URL with the closest-matching time. Thus, if the time of the plot is 2012-07-15T03:40, and if there is an image file named "my_image_2012-07-15T03:45.png", then you will get no image, even though you specified a pattern of "my_image_%Y-%m-%dT%H:%M.png"

In cases of seemingly arbitary mappings between plot dates and URLs, there is yet another option. If you start the *Image Format* file name with "fcn:", then what follows is a user-supplied IDL function that takes the ISO-formatted date+time (e.g., "2013-02-17T13:45") as its single input and returns a URL string as its return value. Your function can also take keyword arguments; add these as comma-separated keyword=value strings. For example, specifying "fcn:myfunction,theta=400,model='GFS"' will call the user-supplied function "myfunction", whose calling sequence should be "url=myfunction(date,theta=theta,model=model)". Of course, you deicde what keywords your function will take when you write it.

For very large images, you can use the *Thin by:* slider to extract every Nth pixel for display on the map.

Somehow, you will need to specify how the corners of the image map into longitudes and latitudes. *X0* and *Y0* give the pixel coordinates of the lower-left corner of the part of the image that you want to use; *lon0* and *lat0* set that pixels' longitude and latitude. In the same way, *X1* and *Y1* give the pixel coordinates of the upper-right corner of the portion of the image that you want to use (-1 means the last pixel position), and *lon1* and *lat1* specify the longitude and latitude of that pixel.

What do you do if you do not know those pixel coordinates? Click on the *demo* button. A new Image Demo panel will appear. Click on the *Get Image* button, and the image should appear. Scroll to the lower-left corner and move your mouse pointer over the left-most, lowest pixel whose longitude and latitude you know. Left-click on that pixel, and *X0* and *Y0* on the External Images widget will automatically be filled in. Now scroll the image to its upper-right corner. Move the mouse pointer over the right-most, uppermost pixel whose longitude and latitude you know, and right-click on that pixel. *X1* and *Y1* on the External Images widget will automatically be filled in.

Now return to the External Images widget, fill in the values that yo know for *lon0*, *lat0*, *lon1*, and *lat1*.

Now click on *OK*, and both widgets will disappear. The image will be mapped into the map display.

5.5 View satellite overpasses?

Part of your flight will involve coordinating measurements with a satellite instrument, so you want to display the satellite measurement locations on a map, labelled with their times, along with your flight track.

Select *Satellite Tracks* from the *Decorations* menu of the Map Display. But of course you will need an external file that contains the overpass data for the satellite insturment(s) whose measurement locations you wish to plot.

The satellite overpass files are plain text files. A file may contain overpasses from multiple instruments or even multiple satellites. A file consists of a sequence of sections, each of which holds data for one instrument on one satellite. Each section starts with a one-line header, which is then followed by any number of lines that contain the overpass information. The section lasts until the next header line.

The header line consists of an instrument name, followed by ":1:1:1.0". Each data line that follows the header consists of a timestamp (in the same "yyyy-mm-ddThh:mm:ss" ISO 8601 format as used elsewhwre throughout the flight planner), the number of pairs of coordinates, and the a latitude and a longitude for each coordinate pair. Note that this satellite tracks decorsation knows only about spots; it does not try to draw lines between spots.

For example, a very short file might look like this:

```
 Aqua:6:8:0.8
2011-09-07T00:09:00  1   -19.98   -155.26
2011-09-07T00:09:30  1   -18.17   -155.68
2011-09-07T00:10:00  1   -16.36   -156.09
MLS-20:3:8:1.0
2011-09-07T00:10:02  1   -19.12   -153.46
2011-09-07T00:10:27  1   -17.64   -153.80
2011-09-07T00:10:52  1   -16.17   -154.13
2011-09-07T00:11:17  1   -14.70   -154.47
2011-09-07T00:11:41  1   -13.22   -154.79
2011-09-07T00:12:06  1   -11.74   -155.12
AquaMODIS:6:8:0.8
2011-09-07T00:39:30  3   -21.19   -169.50  -19.27   -158.51  -16.71   -147.82
2011-09-07T00:40:00  3   -19.40   -169.78  -17.46   -158.92  -14.95   -148.34
2011-09-07T00:40:30  3   -17.62   -170.07  -15.65   -159.33  -13.18   -148.84
2011-09-07T00:41:00  3   -15.83   -170.36  -13.84   -159.73  -11.40   -149.32
2011-09-07T00:41:30  3   -14.04   -170.66  -12.03   -160.13   -9.63   -149.78
```

In the flight planner's *Satellite Tracks* decoration control widget, enter the name of this file. If the file name contains the string "[TD]", then that string will be replaced with the takeoff date, in "YYYY-MM-DD" format. Thus, if your satellite overpass files are suitably named, you need not change the file name specification here every time that you do change the flight.

Next, enter the name of the instrument (e.g., "MLS-20") into the *Instrument* blank. The other key controls that you want to set are *Thin by* (set to 15 to label only every 15th point with tis overpass time) and *Time window (hrs)* (set to 12 hours to display overpass locations that are within plus or minus 6 hours of the plot time.

You can also play around with *Show nearest intercept?* and its associated controls. This causes the flight planner to indicate the closest intercept to the aircraft. This function takes into account not only the spatial distance to the flight track, but the time between the overpass and the moment the aircraft hits the intercept point as well. The results may seem somewhat counterintuitive at times, but they can be helpful.

5.6 Set the locations for sondes to be dropped from an aircraft?

You want to space a set of dropsondes evenly across a long straight-line segment of the flight. You could create a bunch of defined locations, one by one, and carefully position them as exactly as you can over the flight track. But that would be tedious and time-consuming.

So do this instead: just above the list of defined locations on the Flight Plan widget, find the *Auto-gen* menu button. From the menu, select *Gen along line*. A new widget. Generate Locations on a Line will appear. Key in the way points at the ends of your straight-line flight segment as your starting and ending points. Set the interval as the desired distance between dropsondes, as well as how many sonde you want to drop. Change the *Loc. Name Prefix* to something like "D" for easier recognition, and change the *Type Code* to something like "DS" for the same reason.

Now click on *Generate Locations*, and a number of new points will be added to the defined-locations table. Re-plot a Map Display, and the new locations will be plotted on the map.

You can use the same Generate Locations on a Line widget to create dropsonde location along other line segments, Just remember to change the *Starting Index* to be one more than the last location you created. When you are done with the widget, you can dismiss it by clicking the *Done* button.

5.7 Display my model data on a map?

First, write an IDL function to read and return a horizontal or quasi-horizontal slice of your data. The routine must follow the calling sequence decribed in Section 3.5 of Chapter 3. Then in the Map display, select *User-supplied Map Data* from the *Data* menu. Be sure to fill in the name of your function (Leave off the "'.pro" part—you want the routine name here, not the file name), along with any parameters that it needs to select the data that you want.

5.8 Make output for the pilots?

Your pilot would like a list of way points from you, in order, in a file that he can load into a spreadsheet and then copy and paste and paste into a commercial aviation flight planner system.

You probably want a Waypoints Display for this. This is like the Tabular List Display, except it only prints defined locations, and it prints them in the order in which they are encountered. The longitudes latitudes are reported to be the format that the Jeppesen aviation software accepts.

You can filter the points that are displayed by "Type" (see the "Type" column in the defined locations list). This may be useful if you have defined a set of proposed dropsonde locations and labeled them as type "DS". Filter for only the "DS" locations, and you have a list of the dropsonde locations only.

Go to the *File* menu and select *Export this display*. Set the file name that you want, and make sure that it ends with ".csv", so that the output Will be in spreadsheet format. Click on *Save*, and you can send the resulting file to the pilot.

5.9 Determine whether my plan has the plane doubling back on itself?

Your plan has the aircraft going back and forth along a single line between points P1 and P2. After reaching point P2, you turn around towards P1. then you have a dive maneuver that takes the aircraft down to 40 kft, followed by an ascent to 55 kft. Then you want to proceed to P1 at constant altitude. The trouble is, you are having difficulty seeing whether the plane get to P1 before or after it reaches 55 kft. If after, no problem: you just continue to P1. But if it hits P1 first, then continues on in that direction until it reaches 55 kft, then flying to P1 means doubling back and retracing you path to P1 which may not be what you want. The map is no help, since this part of the flight is all on one line.

You have several options. The first is to bring up the Heading vs time display. Another option is to bring up a Time series plot and set it to plot longitude or latitude, whichever varies most along your line. Where you see the heading suddenly change by 180 degrees, or where you see the longitude or latitude doubling back unexpectedly, that is where your plan has the aircraft doubling back.

5.10 Avoid having an instrument staring into the sun?

One of the instrument son the aircraft has an inlet probe that, if pointed directly into the sun, will adversely affect the detectors. Unfortunately, the science goals strongly suggest that you fly towards the east in the early morning hours. How can you avoid pointing this instrument right into the wrong spot?

You want to display the solar zenith and azimuth angles long the flight, and you want to highlight any place in which the sun is, say, ± 3 degrees from the nose of the aircraft.

Bring up the SXA vs time display. From its *Edit* menu, select *SZA Spec*. Set *Azimuths?* to *Yes*. Set *Highlight Azimuths & Zeniths?* to *Yes*. Set *Min Azimuth* to -3 and *Max Azimuth* to 3. Set *Min SZA* to 0 and *Max SZA* to 90. Click on *OK*. Little barbs appear on the SZA plot, indicating the solar azimuth angle with respect to the nose of the aircraft.

And if a time point from the simulation falls within the highlighting limits that you set, that barb will appear in bold. To be safe, though, note in the plot any place where the barbs suddenly shift from port to starboard (or vice versa), and look at what the aircraft is doing then.

Also, if you have access to meteorological data files locally, set the *Met Data* menu, so that the aircraft-relative solar azimuth will be corrected for the cross-winds the aircraft is forecast to encounter in flight.

5.11 Avoid crossing back and forth between two FIRs?

Crossing an FIR boundary is usually no big deal, as long as the necessary paperwork has been filed and approved. But since the pilot has to be handed off from one control center to another when such a boundary is crossed, it is best to avoid going back and forth repeatedly or crossing briefly through a corner of one FIR to get to another, unless you really need to.

So: bring up a Map Display. From the *Decorations* menu, select *FIRs*. Click *OK* on the FIRS control widget. Now you will see all of the FIR boundaries, along with the flight track. And you should be able to tell if your path is going to cause the pilot some headaches with air traffic control.

5.12 Correct timings in my plan for winds?

You can tell from your maps that the aircraft is flying near a jet (a region of high winds, that is, not another aircraft). There will be significant head winds or tail winds, and you want to know how much difference this is going to make in the total flight time.

You will need meteorological data file locally present for this.

Bring up a Tabular Listing Display. Select a source of meteorological data from the *Met data* menu. Use *Add Column* to add Elapsed Time (hrs), and Met Corr. Time (hrs). (Met Time Corr (min) gives you the time difference the winds made, in minutes. Met Corr. Time (hrs) gives you the total elapsed time, corrected for the wind.)

Look at the last line in the table. The difference in the two columns is the difference the winds are forecast to make.

5.13 Put my plan into a writeup in my word processor?

Save your text display in "rtf" format, then open the output file in your word processor.

You can also save your graphical displays in ".png", ".jpg", or ".eps" format, then insert those files into your document.

When you are done, you probably want to use your word processor's use "Save as" function to save the document as something other than rtf format.

5.14 Change way points that are calculated from variables?

Suppose you need to set up a fairly complicated pattern, using functions in expressions to define way points, but when the flight is actually flown you need to be able to adjust individual way points arbitrarily. You can do this in several ways:

1. Start by setting up your pattern in terms of maneuvers and variables. Then generate new locations from the key points in that pattern: go to the *Editing* tab in the main flight planner control, and select *Gen. from key points* from the *Auto-Gen* menu. You might want to set the beginning and ending times to encompass only the maneuver in question. This will create a new defined location for each vertex in your pattern. Delete the maneuvers that make up your pattern. Then add new maneuvers to take the aircraft from location to location. You can use the Map w/ Flt Edit display to do this, setting Maneuver Mode and then clicking from location to location to add the maneuvers.

2. Define a set of locations in the locations table, using the "Specs" field to define all but one of them in terms of the remaining one. Then set up the maneuvers in your pattern to reference these locations as waypoints.

3. Set up maneuvers in your pattern to reference defined locations as waypoints. Then before those maneuvers, insert a series of *define_loc* "Define a location" maneuvers. When these maneuvers are encountered at run-time during the flight simulation, they reach back into the defined-locations table and define (or redefine) those locations. (In contrast, the *define_pos* "Define a position" maneuver defines a variable and does not affect the defined-locations table at all.) You might want to encase these definition maneuvers in an *if-then* pair so that you can turn them off, assuming you don't want the locations redefined every time you click on *Go*.

5.15 Do something with all of the hardcopy files I have exported to?

You have a nice flight plan, with about a dozen displays. You click on *Export this flight's displays* from the *File* menu of the Flight Plan widget, so that a dozen different output files are produced.

Now what do you do? You would like to mail those files to someone, or post them to a web site. But you would like to do them all at cone, automatically, and not have to go through a tedious procedure for each of a dozen individual files.

What you do with your files is of course, well outside the scope of the flight planner software. But you can write a shell script that will take the names of the files as command line arguments and do whatever you need to do to dispose of them, either emailing them to a predetermined address (using "`mutt -a file1 -a file2 someonesomewhere`"), or posting to a web site (using "`curl`").

What the flight planner can do is run this shell script for you, automatically, whenever you click on *Export this flight's displays*. From the Flight Plan widget's *Edit* menu, select *Exported file disposal*. Replace "`ls -l`" in the entry blank with your shell script, then click *OK*.

5.16 Set defaults for my aircraft and directories?

You plan flights for the ER-2. But every time that you start planning a new flight, the flight planner's default aircraft type is the Global Hawk. It's a minor annoyance to change, but you would like to set the default aircraft to your own preference.

Also, you prefer to have separate directories for your flight plan files, your display configuration files, and your exported output files. But it is tedious to type in the path for each. You would like the desired directory to come up each time.

You can do this by using a "`.flightplanrc`" file to store certain default settings. When you first start up the flight planner, it looks for this file in your current working directory. If it does not find it there then it looks in your home directory. Whichever file it finds first, that is the one it reads its defaults from. The file is a plain text file, with each line of the form keyword="value".

The keywords are:

Keyword	Purpose
ac_type	Sets the default aircraft type
plan_dir	Sets the default directory used for reading and saving plan files
config_dir	Sets the default directory used for reading and saving display (and other) configuration files
exports_dir	Sets the default directory used for writing exported display hard-copy files

An example file might look like this:

```
ac_type="er2"
plan_dir="/home/myname/Desktop/flight_planner/Plans"
config_dir="/home/myname/Desktop/flight_planner/Cfgs"
exports_dir="/var/www/htdocs/Flightplans/"
```

Chapter 6

Errors and Recovery

You cannot save an incorrect plan to a file. When you try to save the current plan, the flight planner clicks on its own *Go* button, in effect. If any errors are found, the plan will not be saved.

You cannot add a maneuver to the plan that is missing a required parameter. When you click on *OK* in a maneuver's editing widget, the parameters are checked first, and you cannot quit editing until they are OK.

When you do get an error after clicking on *Go*, the error message is displayed in a red notification panel. Also, the maneuver that had the problem has its indicator light turned to red. Simply scroll down the list of maneuvers in the Flight Plan widget and find the maneuver with the red light. Click on the big button it its center, and edit the maneuver to fix the problem.

If you encounter a bug that crashes the flight planner, but leaves you with an interactive prompt, try typing in "`return`" at that prompt, and keep doing this until the flight planner becomes usable again.. This will sometimes get you back to a place from which you can save your work.

Some crashes seem to involve a rapid sequence of clicking. Click on the control you want, but then wait for the planner to finish before clicking again.

Chapter 7

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